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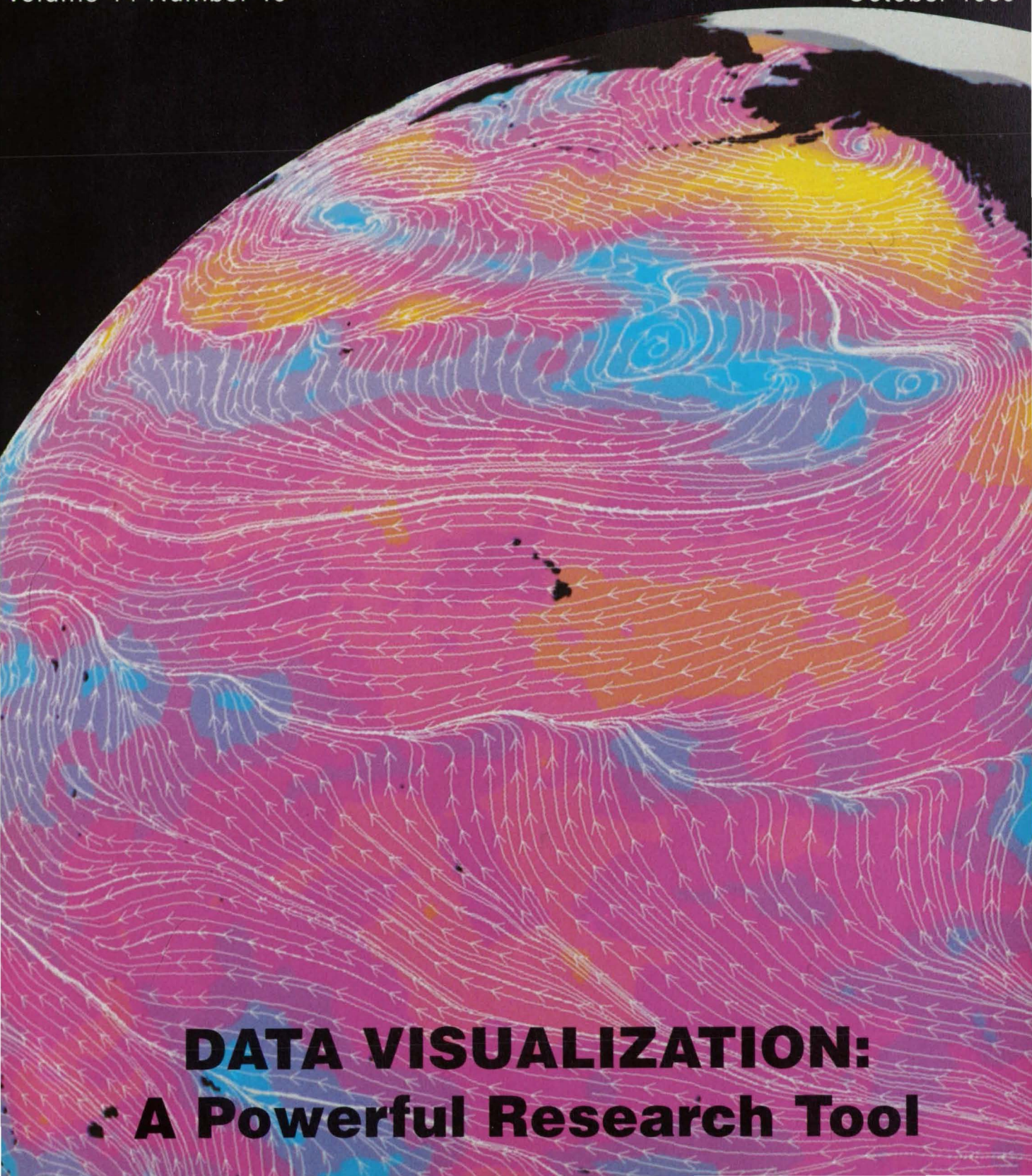
Space Administration
Volume 14 Number 10

Transferring Technology to
American Industry
and Government
October 1990



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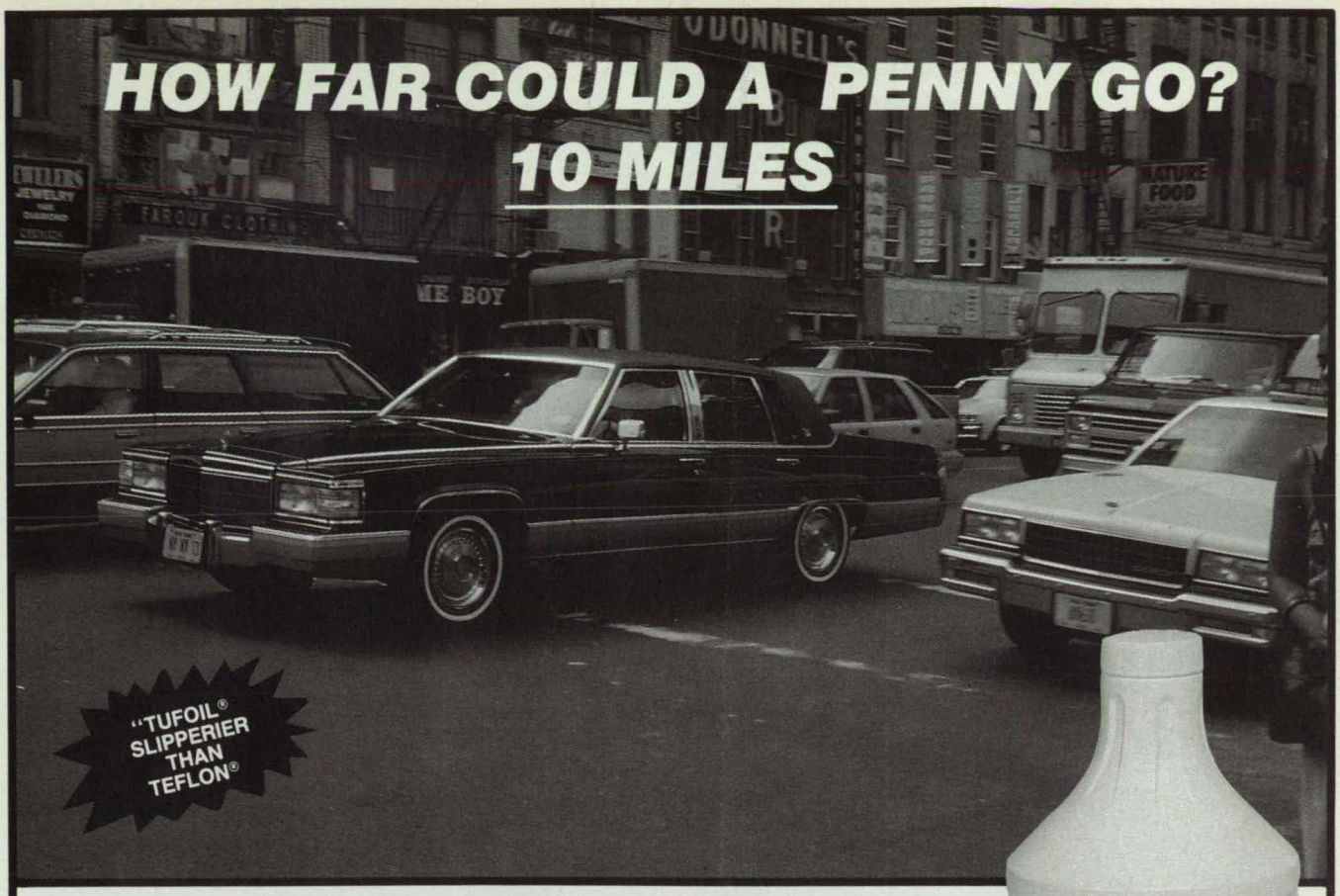

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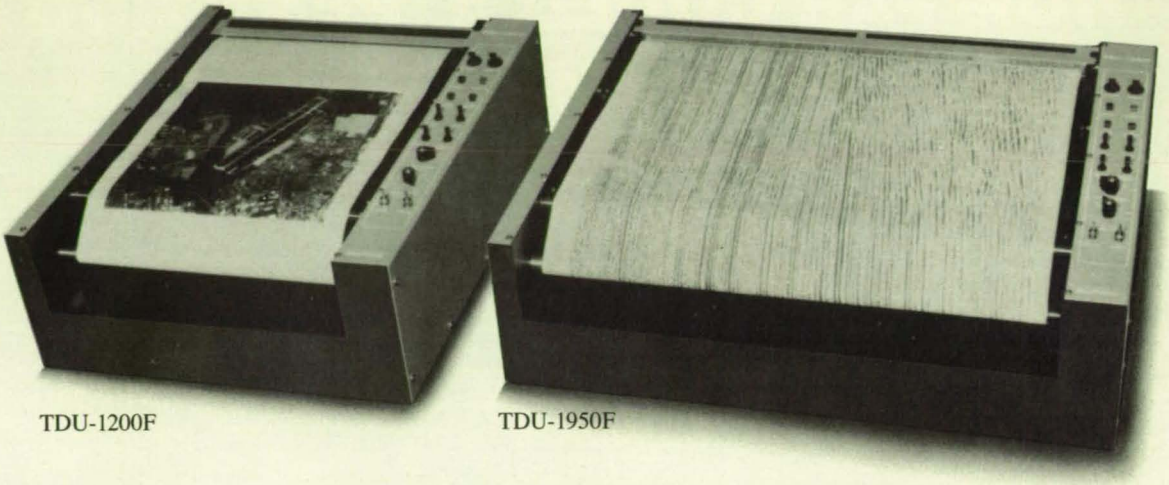


TDU-1200F TDU-1950F

We're widening the scope of hard copy recording.

TDU-1200

TDU-850

Raytheon has added a series of wide "flatbed" models to its quality line of thermal hard copy recorders. The new TDU-1950F and TDU-1200F units, in 19.5 inch (49.5 cm) and 12 inch (30 cm) configurations, respectively, provide enhanced vertical integration of data for a broad range of specialized applications.

The flatbed models join Raytheon's established family of "free fall" thermal recorders – the TDU-850, with an 8.5 inch (21 cm) printing width, and the TDU-1200, with a 12 inch (30 cm) printing width.

Raytheon's thermal recorders produce high resolution copy at high speeds and can generate full tonal images up to 256 multi-shade levels of true grey. Alternately, they can display digital data in crisp graphic or alphanumeric form using an optional IEEE 488 interface.

Traditional uses include CRT hard copy, military surveillance, spectrum analysis, LOFAR gram displays, ultrasonic production control, and facsimile transmissions. New and evolving applications include support for computer assembly testing and chromosome analysis in genetic research.

TDU's print on paper, plastics or transparencies. They feature clean, odor-free, maintenance-free operation.

Make hard copy easy with today's most versatile and reasonably priced thermal recorders. Call or write Marketing Manager, Production Components, Raytheon Company, Submarine Signal Division, 1847 West Main Road, Portsmouth, RI, USA 02871-1087. Phone 401 847-8000.

Raytheon

Circle Reader Action No. 512

DADiSP 2.0

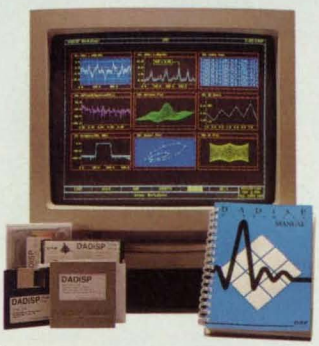
DADiSP. The Big Picture in Signal Processing

DADiSP — interactive graphics and data analysis software for scientists and engineers. DADiSP 2.0 delivers unprecedented power, through easy-to-use menus. Choose from hundreds of analysis functions and graphic views — from tables to 3-D. Simultaneously display multiple windows, each with different data or analyses, for unlimited perspective on your toughest data analysis problems.

Build your own analysis worksheets — build and display an entire signal processing chain, *without programming*. And DADiSP's powerful graphic spreadsheet automatically recalculates and updates the entire chain if you change your data or a processing step.

Do serious signal processing...the way you always pictured it! FFTs, digital filter design, convolutions, waterfall plots, and more — all at the press of a key.

Let your instruments do the talking — use DADiSP-488 to bring data from your instruments directly into a DADiSP window for immediate viewing and analysis.



Flexible, expandable, customizable — annotate your graphs and send them to printers, plotters, or publishing packages. Create your own macros, automate routine tasks, and run any program written in any language from within DADiSP. *DADiSP even lets you build your own menus.*

A proven standard — already used by thousands of engineers and scientists worldwide, in a whole range of applications like medical research, chemistry, vibration analysis, communications, manufacturing quality control, test & measurement, and more. DADiSP supports the IBM PC and PS/2, SUN, DEC VAX, HP 9000 and Concurrent families of personal computers and workstations.

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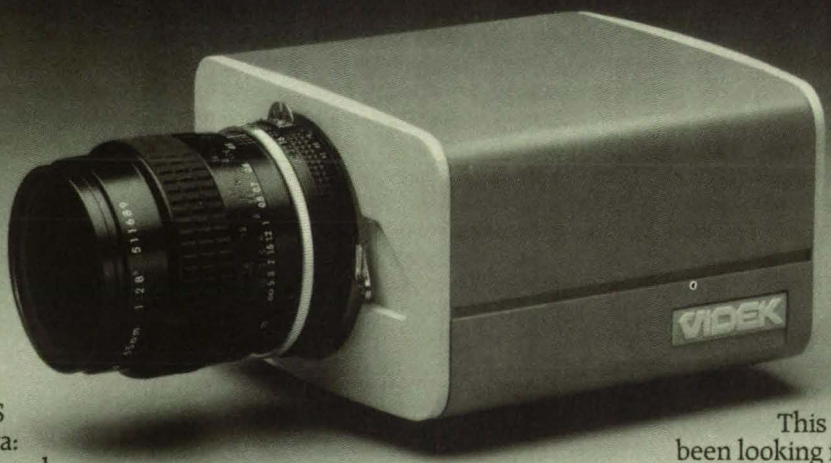

At 1.4 million pixels you don't have to accept anything sight unseen.

The VIDEK MEGAPLUS Solid-State CCD Camera: 1320(H) x 1035(V) pixels and 100% light-sensitive sensor area.

Unique Kodak sensor at actual size. 1320(H) x 1035(V) pixels with 100% fill maximize imaging accuracy.

For maximum resolution and unsurpassed sub-pixel dimensional accuracy. And 8-bit digital output for optimal signal quality.

Advanced Kodak imaging technology closes the information gap!

Make your system look its best.

The VIDEK MEGAPLUS Camera is compatible with products from your current board- or system-level supplier—PC/AT Bus, VME/Sun Bus, and Q/Bus.

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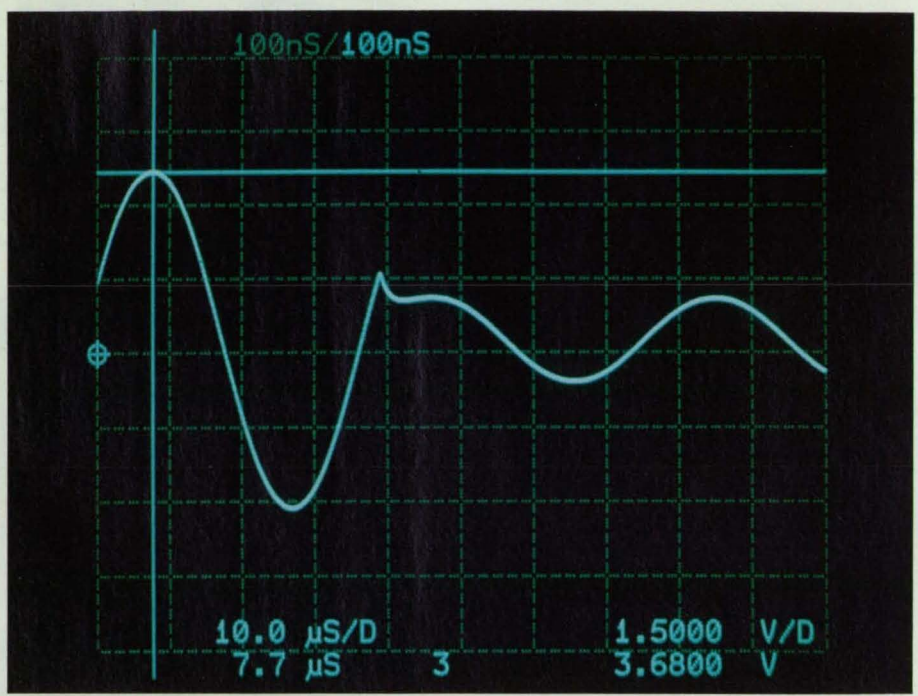

Nicolet 430E: 256K Memory/Channel, 12 bits vertical resolution.

LeCroy 9450:
80 times less resolution
(5 times less horiz.,
16 times less vert.)

Tektronix DSA602:
208 times less resolution
(13 times less horiz.,
16 times less vert.)

Hewlett Packard 54112D:
256 times less resolution
(4 times less horiz.,
64 times less vert.)

Fluke PM 3323:
256 times less resolution
(64 times less horiz.,
4 times less vert.)

There's more of everything with the Nicolet 400 Series.

Any way you look at it, competitors just can't touch the Nicolet 400 Series when you consider memory and vertical resolution.

The closest major competitor's per-channel memory is four times less. Vertical resolution—four times less again. And when memory and vertical resolution are combined, the nearest offering is 80 times less! Clearly no match.*

Now add other 400 Series advantages like the choice of two or four channels, with 64K to 256K memory in each. Single ended or differential inputs. A 3½" or 5¼" floppy drive. One to 200 MS/s digitizing rates. The unique 44 MB removable hard disk or 40 MB internal disk. Plus dual timebase, choice of 8 or 12 bit digitizing resolution (separate or combined); built in MS-DOS drive; LEARN mode for automated test sequences; FFT and averaging.

More individual features, more combined memory and vertical resolution, more of everything. Get the picture?

Call today about the Nicolet 400.

*Based upon known specifications as of 7/90.

Nicolet Test Instruments Division

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Nicolet
INSTRUMENTS OF DISCOVERY

Circle Reader Action No. 696

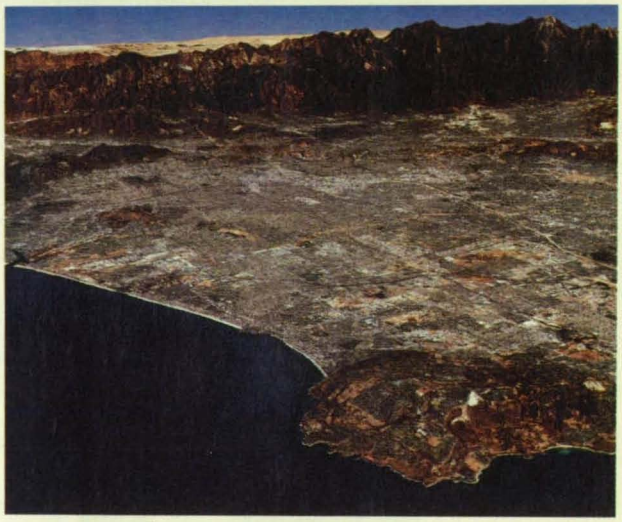
NASA Tech Briefs

Transferring Technology to
American Industry and Government

October 1990
Volume 14 Number 10

Photos courtesy Jet Propulsion Laboratory

Imaging experts at Jet Propulsion Laboratory reprocessed this Landsat photo of the Los Angeles area to create the synthetic perspective view below. The 3D image is one of over 3000 frames of "LA: The Movie," a realistic simulated flight over the entire city. *Turn to page 106.*



SPECIAL FEATURES

TECHNICAL SECTION

DEPARTMENTS

On The Cover: The emerging field of Scientific Data Visualization offers powerful new tools to help scientists and laymen to quickly and easily understand massive amounts of information, as demonstrated by this month's cover photo. Researchers used advanced image processing techniques to convert remote sensing data into a picture (partially shown) of global wind speed and direction. The arrows indicate wind direction and the colors represent wind speed, with blue being the lowest wind velocity and yellow the highest. The image was created by Peter Woiceshyn and Andrew Pursh of Jet Propulsion Laboratory, Professor Morton Wurtele of UCLA, and Dr. Stephen Peteherych of the Canadian Atmospheric Environment Service. *See page 106.*

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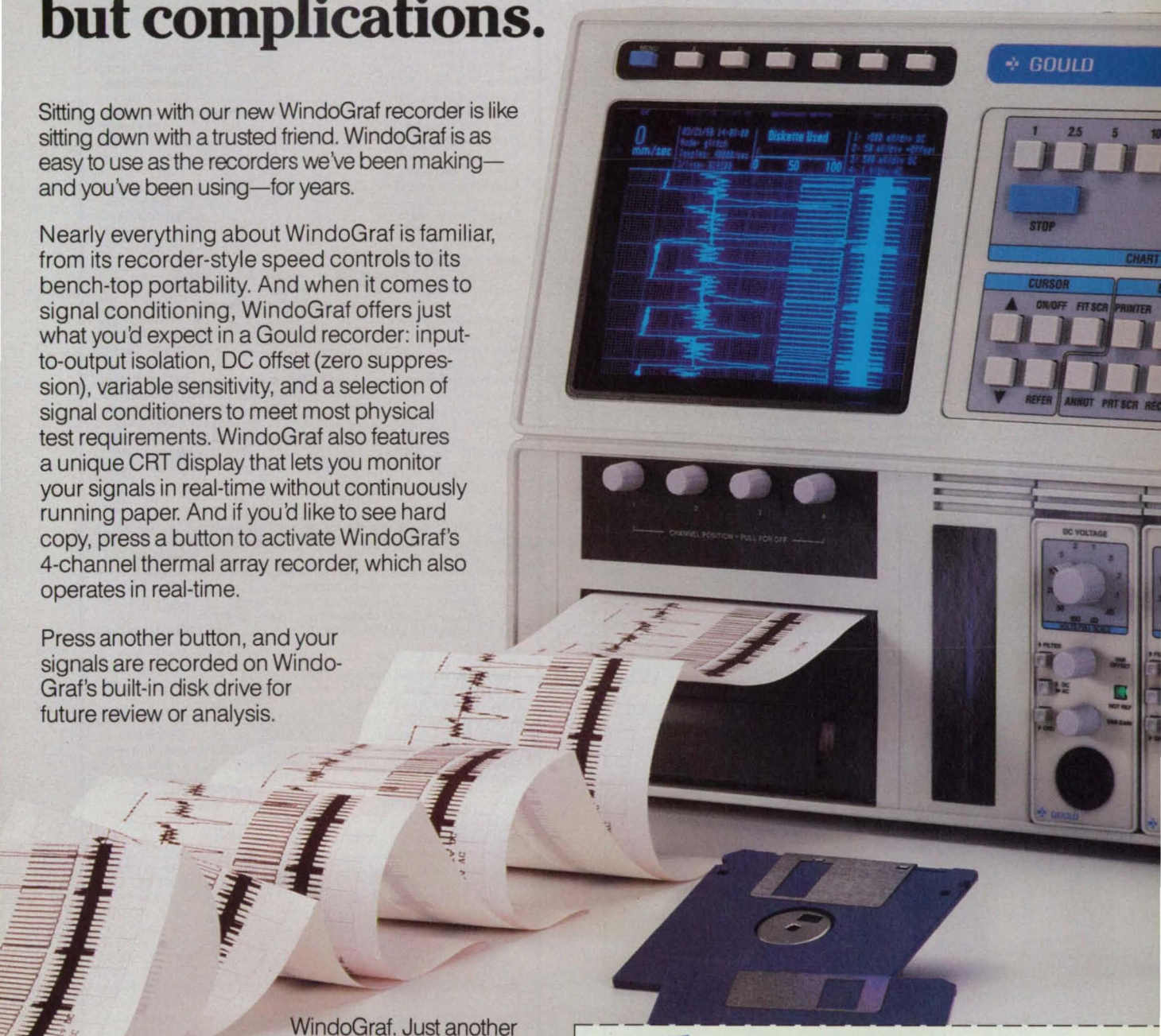
Our new recorder comes with everything but complications.

Sitting down with our new WindoGraf recorder is like sitting down with a trusted friend. WindoGraf is as easy to use as the recorders we've been making—and you've been using—for years.

Nearly everything about WindoGraf is familiar, from its recorder-style speed controls to its bench-top portability. And when it comes to signal conditioning, WindoGraf offers just what you'd expect in a Gould recorder: input-to-output isolation, DC offset (zero suppression), variable sensitivity, and a selection of signal conditioners to meet most physical test requirements. WindoGraf also features a unique CRT display that lets you monitor your signals in real-time without continuously running paper. And if you'd like to see hard copy, press a button to activate WindoGraf's 4-channel thermal array recorder, which also operates in real-time.

Press another button, and your signals are recorded on WindoGraf's built-in disk drive for future review or analysis.



WindoGraf. Just another way Gould is helping you meet your physical test and measurement needs . . . without complications.

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Free demo disk!

Yes! Show me how Gould's new WindoGraf is as simple as it is advanced!

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ABP BPA

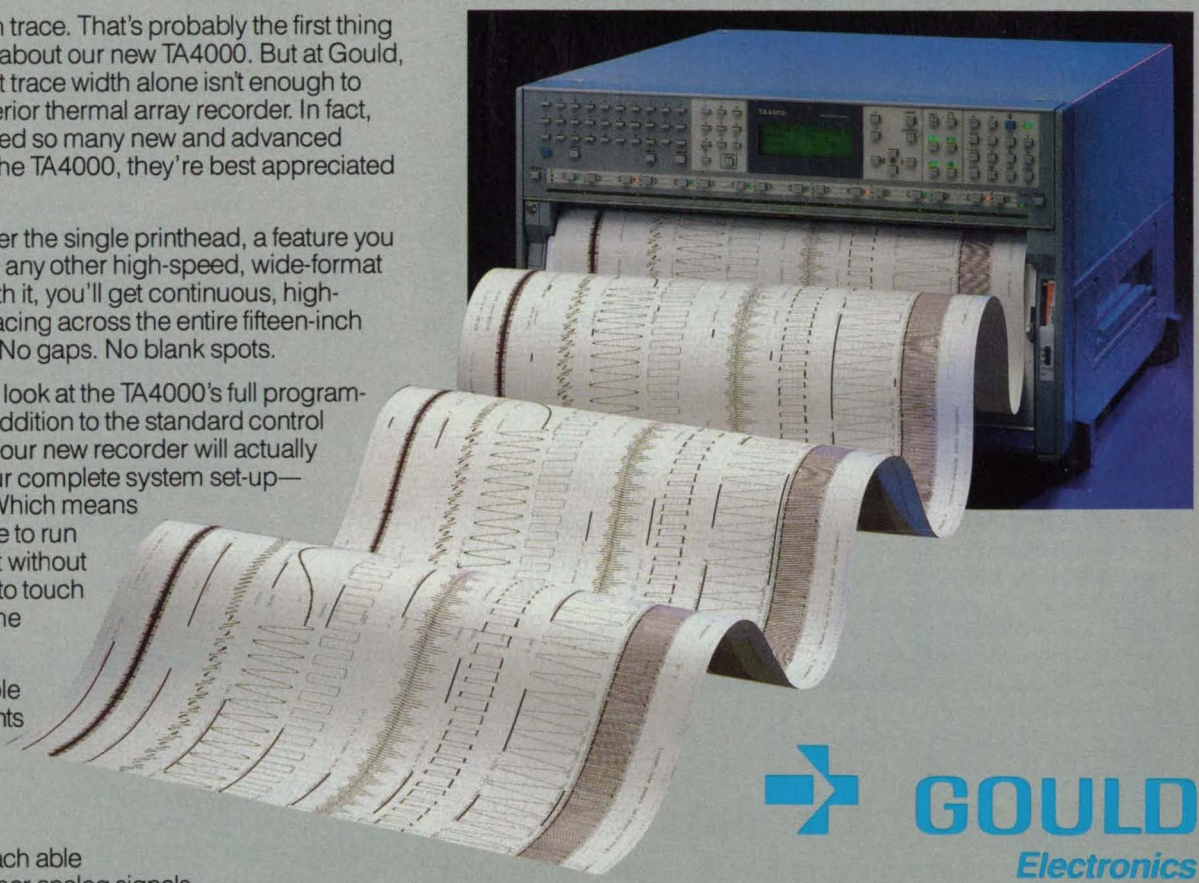
The best way to appreciate our new thermal array?

Inch by inch.

A fifteen-inch trace. That's probably the first thing you'll notice about our new TA4000. But at Gould, we know that trace width alone isn't enough to make a superior thermal array recorder. In fact, we've included so many new and advanced features on the TA4000, they're best appreciated one by one.

First, consider the single printhead, a feature you won't find on any other high-speed, wide-format recorder. With it, you'll get continuous, high-resolution tracing across the entire fifteen-inch chart width. No gaps. No blank spots.

Then have a look at the TA4000's full programmability. In addition to the standard control capabilities, our new recorder will actually calibrate your complete system set-up—all by itself. Which means you'll be able to run an entire test without ever having to touch or readjust the instrument.



And if multiple measurements are what you're after, the TA4000 has up to 24 channels, each able to handle either analog signals or digitized data. What's more, our new recorder will simultaneously record analog and digitized inputs, giving you maximum measurement flexibility.

Of course, the TA4000 is push-button simple. It's designed for maintenance efficiency. And it features Micropulsing™, a new technology that extends thermal array head life and increases contrast quality.

But why measure the TA4000 by words alone?

Call your Gould representative today to schedule your own demonstration. They'll answer any questions you may have. They'll provide you with product specifications. And together, you'll cover all the benefits of the TA4000. Inch by inch.

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Yes! I want to see how Gould measures up! Please send me more information about the TA4000.

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New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 18). NASA's patent-licensing program to encourage commercial development is described on page 18.

Braided Composite Threaded Fasteners

A proposed braiding-and-molding process for fasteners of carbon/carbon or of other fiber/matrix composite materials would cost less, produce stronger product, and be adaptable to mass production. These fasteners are intended for use with ceramic and composite-material structural parts at temperatures exceeding 2,500 °F (1,400°).

(See page 94)

Ultrasonic Imaging of Deep Arteries

An ultrasonic medical instrument using swept-frequency sound produces images of peripheral and coronary arteries with resolutions higher and at depths greater than those attainable by previous ultrasonic systems. Calculations have shown a 53-dB improvement in processing gain over a pulse-echo system.

(See page 54)

Neural-Network Processor Would Allocate Resources

A proposed artificial neural network would perform a globally optimal allocation of M resources among N expenditures according to a prescribed set of rules. Potential applications include the assignment of jobs, scheduling, dispatching, and planning.

(See page 46)

Two-Way Optical Data Link on One Fiber

An optoelectronic terminal for digital communication both transmits and receives over a single optical fiber. Although the maximum possible data rate is only half that of a two-fiber, full-duplex link, the cost of the single-fiber link could be much lower.

(See page 31)

Annular-Bragg-Grating Surface-Emitting Laser

A proposed semiconductor laser would emit radiation perpendicularly to its broad surface by use of an annular Bragg grating as the output coupler. Such a laser is expected to be smaller, to have lower threshold current, and to be more efficient than those using conventional grating.

(See page 20)

Integrated Process for Insertion and Beatup of Fill Yarns

An integrated apparatus and process have been devised for the insertion and beatup of fill yarns during the weaving of fabrics containing bias-oriented yarns. The apparatus and process are intended for use in the angle-ply or bias-direction weaving.

(See page 92)

GOULD
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Gould recorders show up in the most convenient places.

Introducing the first family of digital recording oscilloscopes.

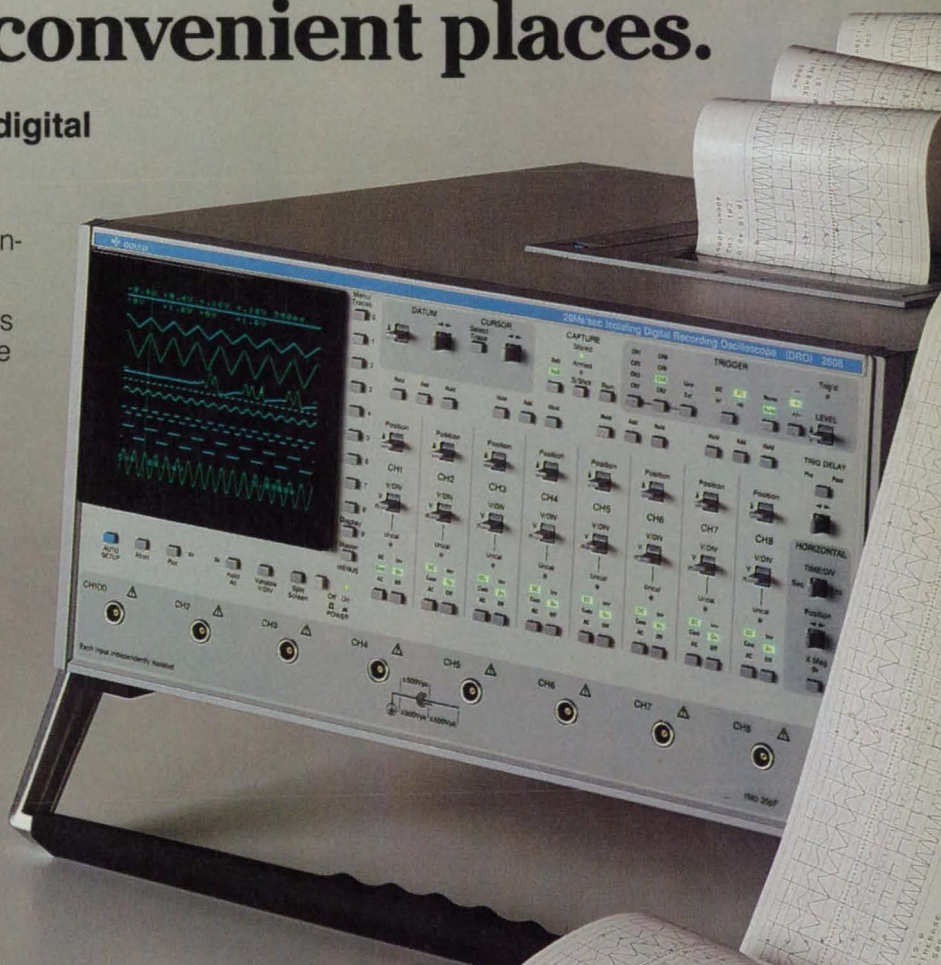
Now you can get the power of a digital storage oscilloscope with the built-in convenience of traditional recording.

Gould recognizes that physical testing is extremely demanding. That's why we've designed a family of Digital Recording Oscilloscopes (DROs™) with features that let you:

- ☐ Capture and record up to eight channels simultaneously
- ☐ Record off-ground measurements with isolated or differential inputs
- ☐ Capture and record single shot events with 50 nanosecond resolution
- ☐ Use the built-in thermal array recorder for:
  - – continuous trend recording
  - – screen dump of selected data
  - – output of a segment of memory or the complete memory

All this in a single, portable package.

For more information and a free Gould Guide to DSO/DROs diskette, call (216) 328-7000 or use the coupon below. Because if you think the Gould DRO sounds good, you ought to see it on paper.



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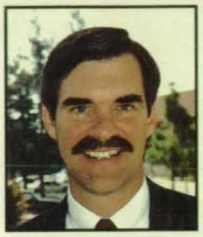
The Winners:

The Top Letters Supporting The Space Exploration Initiative

"Space exploration provides a source of pride and a sense of purpose for the country," penned David Jones in an insightful and inspiring letter that earned top honors in the *NASA Tech Briefs*/National Space Society 1990 Letter Writing Contest. Announced in June, the contest generated over 500 letters to various elected representatives in support of President Bush's Space Exploration Initiative. The complete list of entrants—every one a winner—appears on page 16.

Grand Prize Winner



David A. Jones, Bakersfield, CA

Dear Senator Wilson:

Please support the Space Exploration Initiative.

A few people do not support space exploration. Their arguments usually boil down to this: "With all the problems we have on Earth, we can't afford to spend money on space."

I can't argue with the premise of this statement. We do have problems. However, if we spent the entire space budget, and a whole lot more here on Earth, we would still have problems.

Still, prudent people acknowledge that space exploration must compete with a host of worthy alternatives for funding. Is it worth it? Are there sound reasons to spend precious resources on space exploration? Space exploration is worth the price, but sometimes it takes vision to recognize it.

Vision to recognize that space exploration provides a source of pride, and sense of purpose for the country. We need a goal to avoid stagnation and complacency, and a yardstick to measure our advancement. In some countries, military might has served this purpose, but space exploration is a far healthier alternative.

Vision to recognize that pure scientific research is a strong and valid aspect of human endeavor. Throughout the history of mankind, a nation's skill in science has been one of the most important measures of an advanced and civilized society. Like art, science is a means of expression, one of the things that satisfies our fundamental needs as human beings.

Vision to recognize that money spent on space exploration doesn't disappear into a black hole. It is reinvested in our economy. Sometimes a project is promoted with the argument that it creates jobs. Often this contention is hollow because those jobs do not produce any tangible benefit for the country. But with space exploration, one of the greatest dividends is what this money buys. It builds a scientific and engineering foundation within industry, the university system and the government that allows us to lead the world in scientific achievement. Space exploration directly produces many valuable products and services, but it is the associated scientific and engineering infrastructure that is the unseen, but irreplaceable benefit.

The vision to look past the short term problems on earth to the long term solutions in the stars. Five hundred years ago, Queen Isabella of Spain supported a voyage of discovery. She had many problems and was hoping that a shorter route to the east would provide some solutions. There were many surprises. The passage to the east was not to be, and it was many years before Spain profited from the venture. However, Spain did flourish and built an empire in the new world. Now, after 500 years the glory of that empire has faded. But the legacy of that voyage is unsurpassed. A whole new world exists. Civilization will never be the same.

Space exploration provides wonderful rewards right now, but like the exploration of the new world, the ultimate dividend may take hundreds of years to be fully realized. Still, that payoff will be the most momentous in all of history. Let's have the vision to make it happen.

Please support the Space Exploration Initiative.

Sincerely,
David A. Jones, Bakersfield, CA

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

David Jones, 42, is a senior petroleum analyst for Occidental Petroleum Corp. in Bakersville, CA. He holds a B.S. degree in Geology from Oklahoma State University and an MBA from the University of Texas. Mr. Jones is married and has a three-year-old son and six-month-old daughter. He has won a tuition-free stay at the United States Space Camp.

Second Prize Winner

Michael J. HaverKamp, Lincoln, Nebraska

Senator Exon,

My son is three years old. Yesterday he asked me to take him on a ride in a spaceship. You see, he takes the idea of space travel quite for granted, just as I did growing up. I dreamed about space, and wanted very much to share the experiences of men like John Glenn and Neil Armstrong. I'm 34 now, and more cynical, so the dream isn't as strong as it used to be. The responsibilities of a family have distracted me somewhat, but the cynicism comes from seeing the space exploration effort turned into empty political rhetoric.

As an engineer, I have a solid understanding of what we are technologically capable of doing in space. We could have done so much by now, if we hadn't turned away. Perhaps I could have told my son that his dad had already been in space.

It was not so long ago that the "experts" claimed the great American Desert was uninhabitable. The hostile environment would prevent the region from ever being useful, or so they said. Now the "Heartland" is the breadbasket of the world. The taming of the Midwest reflects the spirit and drive that built this country. Where is that spirit now? I grew up hearing about the sacrifices made and the risks faced by our grandparents in their time. Have we become too timid and self-centered to face the challenges of our own time?

Shall I tell my son that the "experts" say that space is not inhabitable? That it has no useful purpose? That we have chosen to stop exploring space? If we turn away from the challenge of space, what will history say about our time?

I'd like to be able to assure my son that someday he'll get that ride. I'd like to tell him that his father's generation has held true to the tradition and legacy that drove our parents, and their parents before them. That we had found the resources and made the sacrifices necessary to open the door to space permanently. But I'd be lying to him, because we haven't done that, at least not yet.

The Space Exploration Initiative is a symbol of the challenge we face. President Bush has asked us to take up that challenge, to refocus our attention on the exploration and taming of space.

Senator, our generation sent men to the moon. What will our children be able to say that they have done, in their time? Senator, what shall I tell my son?

Sincerely,
Michael J. HaverKamp,
Lincoln, Nebraska

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Michael HaverKamp, 34, is a managing engineer for Brunswick Corporation in Lincoln, NE. He has a B.S. degree in industrial engineering from the University of Nebraska and is working towards his master's degree in management systems engineering. He and his wife Maryjo have an eight-year-old daughter and a three-year-old son. Mr. HaverKamp has won a VIP invitation to a space shuttle launch.

☆ ☆

Children's Prize Winner

Thomas Rampelberg, San Jose, CA

Dear Senator Pete Wilson,

Good day. My name is Thomas Rampelberg and I am eight years old. I like riddles and made one just for you.

President Bush requested it.
One billion dollars in his budget fit.
To take us to Mars
A New Frontier in the stars.
What is it?

I'm sure you know "it" is the Space Exploration Initiative.

I want you to know that I think Space Exploration is important for America. As peace approaches, we need a challenge:

"A journey into tomorrow —
A journey to another planet —
A manned mission to Mars by 2019."
—President Bush

Space is exciting. There are millions of things to learn and discoveries to make. We may find cures for diseases, new places to live, and things that will make our lives better. God would want us to try.

Please support the Space Exploration Initiative. Thank you for reading my letter. If you have time, let me know what you think.

Yours very truly,
Thomas Rampelberg,
San Jose, CA

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Thomas Rampelberg is schooled at home in San Jose, CA, by his mother, Diane, a University of Montana graduate and teacher for the past 18 years, and his father, Michael, marketing manager for Siemens Component Inc. Thomas is a cub scout and plays soccer and baseball. He also sings in the choir at the Christian Community Church, Sunnyvale, CA, and likes to build model spaceships. Thomas has won a tuition-free stay at the U.S. Space Camp.

Merit Winner
Jody D. Backer, Carthage, MO

Dear Congressman Traxler:

Our country has been adrift in space for far too many years without a true statement of why we need a strong space exploration program. The commonly stated reasons— economic, political, technological leadership — are all quite true, but they fail to excite the imagination of the American public. At its core, the human race craves adventure; we are a nomadic people, gaining strength and cunning through facing the challenge of unknown lands and changing conditions. It is when we become complacent that we grow soft, docile and ultimately turn in upon ourselves. It is at this point that a spiral of decay sets in.

Now, as a country, indeed, as a race, we find ourselves at this point. Space, a limitless arena for our questing souls, beckons. We must go forward with the Space Exploration Initiative for our own well-being. For the first time, we, as a nation, have a chance to build a space program upon one solid bedrock truth; we do it because it is what we do best. We explore. It is what keeps us young and vital.

Accidents and technological glitches may make us doubt ourselves. Economic conditions may make it seem unwise to invest the money. But these are transitory things; for our future survival, we must go forward. The earth is our mother, our cradle and our home, but it can also be an ever shrinking prison of limitations that will eventually extinguish the spark that makes us truly unique. America can either honor its pioneering heritage with the Space Exploration Initiative, or settle in for the long, painful decline that comes with a loss of will and vision. The choice is as simple — and as fateful— as that.

Sincerely yours,
Jody D. Backer, Carthage, MO

Merit Winner
Kevin Ramanja, Stockton, CA

My Dear Mr. Cranston:

We are coming to an end of this century and our imaginations have caught a brief but exciting glimpse of what the future may have in store for us. I'm sure all of us agree that the human race is moving forward in a positive direction more quickly than ever in its history. The Berlin Wall has tumbled, the people of Eastern Europe are free to live democratic lives, apartheid in South Africa is dissolving, there is a new global awareness of the earth's environment. The world is changing so rapidly we haven't even had time to absorb the greatness of these historical events. However, there is one area that is having quite a difficult time adapting to these changes because of the lack of Congressional support. This area is the further exploration of space.

During the Kennedy era the nation was passionate about becoming the first to the moon. It is a triumph that forever has its place on the top of the list of U.S. achievements. We are still a country that the world views as a leader. In recent years, however, the enthusiasm of the people has subsided. Reviving the space program is the spark that the people need to rekindle their eagerness to advance. Their are many arguments that we should put a manned mission to Mars on the "back burner" because of the problems we have here on Earth. If humankind delayed its growth and expansion to perfect its present state it would never evolve, but a project of this magnitude could be taken in a comfortable stride. A manned mission to Mars could very well help solve some of the problems that we have. It would certainly add zest to the hearts of the people.

Many new medical, agricultural, industrial, and electronic devices have been developed as a direct result of the profound 30-year investment of time, money, and labor spent toward furthering our knowledge of the cosmos. The common pocket calculator, now taken for granted, was developed and popularized by our space program. Advanced satellite surveillance of the planet Venus has opened our eyes to what may become of earth if we continue polluting the environment.

The human race has not achieved the position that they have by sitting back and finding excuses not to move forward. Progress is like a snowball; once you've pushed it down the mountain it gains more and more momentum and becomes unstoppable. No force in the universe can douse the fire that exists in humankind. We will always strive forward. Congress can only delay the inevitable. We urge you and your fellow politicians to support this cause.

Very truly yours,
Kevin Ramanja, Stockton, CA

Merit Winner
Mischell R. Shapiro, Omaha, NE

Dear Senator,

I am writing with regard to the $1 billion requested by Pres. Bush for the fiscal year 1991 budget that will be used for the Space Program.

The rights, privileges, and responsibilities of government are many and extremely diversified. But it cannot be argued that the responsibility of the government is to do for the people what the people cannot do for themselves. Not what the people will not do, but what they simply cannot do. We must put our priorities straight. My neighbors and I can cure the social ills in our cities, as can other members of this abundant land, but we cannot put a man on the moon. We can educate our families, but we cannot build spacestations. Only the government can be the leader in accomplishing this great task.

A recent government survey revealed that most of our social problems are the result of poor self esteem. Corruption continues to seep into the programs meant to help our citizens; as a nation we continue to be mired in our own problems, being "Me" oriented and selfish, and we will drown in misery. However, if we are able to lift our gaze toward the heavens, give us that little triumph that can lead to further success, we may be able to emerge from the inundating disorder. We need direction and example of positive mental health, looking toward a future full of accomplishment and positive self esteem through hard work and goal setting. Our nation needs, if you will, a hobbie. We need an area to place our focus that is away from our problems but will also help solve those problems. We need an area of interest that will encourage our citizens to be educated. We need goals; something to believe in. I believe the space program can nuture us emotionally and give our country the reasons we need to grow beyond ourselves.

I encourage you to help our nation successfully go where no man has gone before by supporting the president's Space Exploration Initiative.

Sincerely,
Mischell R. Shapiro, Omaha, Nebraska

Merit Winner
Harold Reed, Benton, KY

Dear Representative Perkins,

As a resident of Kentucky I would like to know if you will support the Lunar-Mars exploration parts of the upcoming NASA budget. I believe that the returns on the technologies developed in such an effort will dwarf the costs. America must step out aggressively to retain her world leadership position and technological competitiveness. Kentucky will benefit greatly from this investment for the future. Our children must see in us values higher than mere domestic subsistence if we expect them to become anything more than profligate consumers.

There will never be budgets that are not tight. There will never be a time when the public money should not be spent carefully. Those who are not aware of the functional necessity to retain curiosity or understand the human imperative of exploration will never find the "extra money" to begin.

As we become a more complicated and advanced civilization, we must increase the proportion of our expenditures for tool building through technology. We must look ahead, through exploration, for answers to questions that certainly will prove vital for our survival. One questions whether we would have discovered, let alone deal with, the atmospheric difficulties posed by ozone depletion and global warming without the space program. History teaches us that there will be new unanticipated challenges that a sedentary people will not be able to meet.

I request your position on this issue of the exploration portion of President Bush's budget for NASA in the coming year. Your consideration for these technology studies will be appreciated.

Thank you,
Harold Reed, Benton, KY

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Merit Winner
Jeffrey R. Carter, Littleton, CO

Dear Sir:

Last July, President Bush established the Space Exploration Initiative, proposing the space station Freedom, a permanent manned moon base, and a manned mission to Mars. These are laudable ideas, but must be supported with money to come to fruition.

Some question the wisdom of spending money on the exploration of space. They point out that America is plagued by drug use; that we cannot provide food, housing, and medical care for our poor. They argue that money would be better spent on these programs than on space exploration.

Drugs are a concern, not because they are illegal, immoral, or physically destructive, but because they are a symptom of the desperation of those young people who live in poverty surrounded by the American dream. These people turn to drugs as an escape from their condition. Thus, drugs can be seen as a by-product of America's inability to care for its poor.

There are several factors responsible for poverty, including cultural and educational factors, but one factor is the economy. If we can improve the economy, create new, well-paid jobs, and increase the standard of living, we can remove one of poverty's factors, and provide an incentive for young people to forsake drugs for the rewards of a good education.

In reviewing the effect of government programs on the economy, we find that the one program which has had the greatest effect on the economy per dollar spent is space exploration. The new technology needed for space exploration is incorporated in new products and services, which create new jobs and expand the economy. From digital watches to video games, from calculators to satellite TV,— all exist because of the space program. Every month, NASA Tech Briefs magazine presents hundreds of new technology breakthroughs for American industry to incorporate into new products and services.

In addition, the space program's technology is responsible for many recent advances in medical technology. These allow better medical care to be provided for lower cost, resulting in longer lives of better quality. My grandfather, born before the first airplane flight, had a life expectancy at birth of forty-five years. He recently celebrated his ninetieth birthday, thanks to the space program.

A recent innovation demonstrates all these factors. A thermometer which can be swallowed has been developed, thanks to recent NASA technological advances. This thermometer is more accurate than traditional thermometers, allows temperatures to be monitored while the patient walks around, and is the only way to measure the temperature deep inside the body. Who will create new jobs producing and marketing this and similar devices? Who will receive better medical care, perhaps living instead of dying?

Finally, America has always been a land of pioneers, challenging new frontiers. Space is the last and only frontier we have left. If we do not accept the challenge of the last and infinite frontier, we can no longer truly call ourselves American.

We can maintain our nation's technological leadership, motivate our young people, improve our economy, and increase our quality of life, all for a fraction of a percent of the total budget. I urge you to support the requested one billion dollar budget for the Space Exploration Initiative.

Sincerely,
Jeffrey R.Carter, Littleton, CO

☆ ☆

Honor Roll

These are the concerned citizens who participated in *NASA Tech Briefs* /National Space Society 1990 Letter Writing contest in support of the President's Space Exploration Initiative:

Claudia Abrantes, Oriskany, NY ★ April Andreatta, Oklahoma City, OK ★ Timothy A. Aumann, Madison, AL ★ Judy D. Backer, Carthage, MD ★ Lawrence Baldwin, Louisville, KY ★ Russell A. Battista, Acton, MA ★ Amanda Bell, Toledo, OH ★ Robert Bland, Berkeley Heights, NJ ★ Julia Blake, Titusville, FL ★ Terry Blanton, Lilburn, GA ★ Eric Borreson, Glendale, WI ★ Janet Boyens, Everly, IA ★ Kevin Boyens, Everly, IA ★ Charles A. Bragg, Newburyport, MA ★ Diane Bragg, Titusville, FL ★ Robert Brennecke, Matawan, NJ ★ James Brooks, Nashville, TN ★ Richard Brown, Medina, OH ★Adrian M. Brush, Crawfordsville, IN ★ Stephen C. Buol, Cedar Rapids, IA ★ Mark R. Burdick, Binghamton, NY ★ Christopher Butler, Union, NJ ★ Davis C. Caldwell, Connersville, IN ★ Rebecca Canfield, Newark, OH ★ Patricia Carreon, Springfield, VA ★ Jeffrey R. 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Gannatal, Camarillo, CA ★ Sumedha Garud (address unknown) ★ Jaime Gaug, Bloomington, MN ★ Del Gordon, Reston, VA ★ Tara Narcross Gorka, Columbus, OH ★ Jennifer R. Goshe, Tiffin, OH ★ Greg Grant, Titusville, FL ★ Kelly Guenther, Chicago, IL ★ Laura Guest, Torrington, CT ★ Lynn Gunn, Titusville, FL ★ Jeanette Hancock, Los Altos, CA ★ Robert W. Hareland, Albuquerque, NM ★ Jessica Harris, St. Marys, OH ★ Christine E. Haven, Bath, PA ★ Michael J. Haverkamp, Lincoln, NE ★ Houman Hemmati, Encino, CA ★ Amity Helton, University City, MO ★ Walter B. Hendrickson, Jr., Jacksonville, IL ★ Heide L. Herrmann, Snyder, NY ★ Suzanne Hodge, Satellite Beach, FL ★ Adam Hoffman, Marsland, NE ★ Cres Holcombe, Farragut, TN ★ Justin Holcombe, Farragut, TN ★ Bill Hope, Laura, OH ★ David Huff, Jacksonville, IL ★ Harry D. Hung, Watchung, NJ ★ James F. Jackson, Carlisle, IN ★ Rory D. Jackson, Eastchester, NY ★ Steven James, Wichita, KS ★ David A. Jones, Bakersfield, CA ★ John Jones, Jonesville, LA ★ Linda Judd, Titusville, FL ★ Lawrence R. Kellerman, Iowa City, IA ★ Linda Kenny-Sloan, Belleville, IL ★ Donald Kinsworthy, Dayton, OH ★ Jonathan D. Kline, West Bend, WI ★ Nancy Kobryn, Utica, NY ★ Dennis M. Kotz, North Augusta, SC ★ Harold Larkin, Titusville, FL ★ Laurie M. Laughlin, Medford, NJ ★ William J. Lauto, Jericho, NY ★ William H. Ledford, Eunice, LA ★ Jessica Ann LoPresti, Ansonia, CT ★ Carroll D. Lowe, Raleigh, NC ★ Keith G. Lyon, Playa del Rey, CA ★ Victoria L. Lyon, Playa del Rey, CA ★ Lee V. Mangold, Orlando, FL ★ Anthony Marrs, Albuquerque, NM ★ Barbara A. Matthews, Strafford, MO ★ Lee McKinney, Birmingham, AL ★ Chad S. Michael, Edwall, WA ★ Susan Morgan, Titusville, FL ★ Kimberly A. Nardine, White River Jct., VT ★ Jerry P. Parmeley, Washington, DC ★ Daniel J. Pettinati, Ambler, PA ★ C. Gary Phifer, Columbia, SC ★ Russell J. 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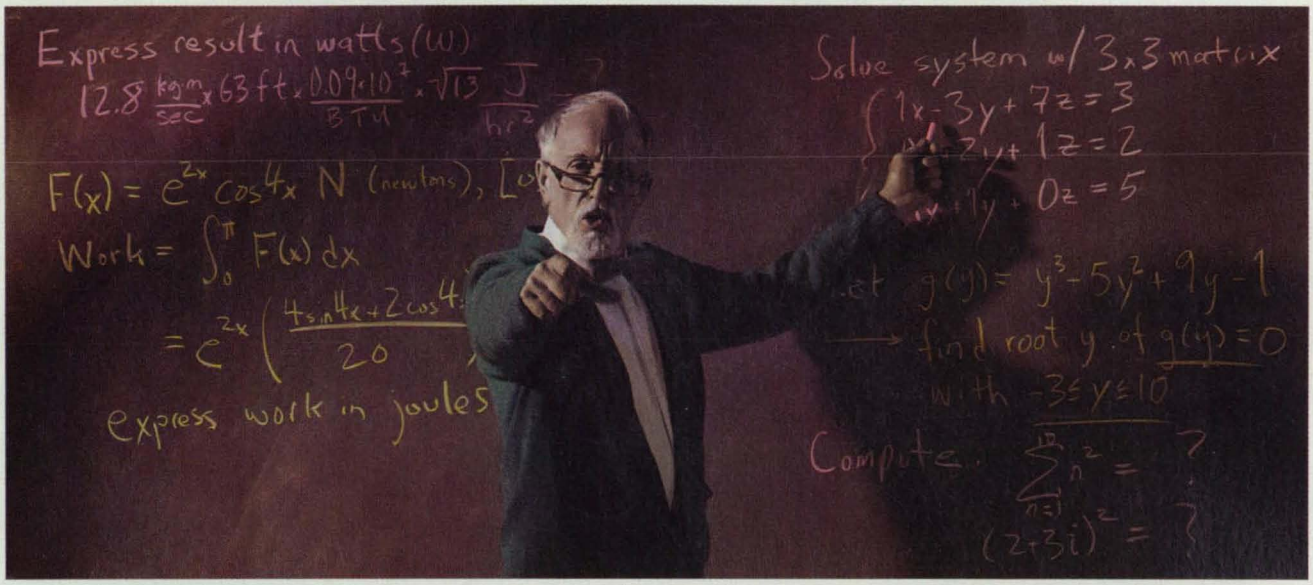

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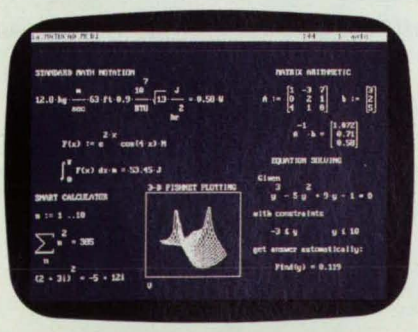

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Annular-Bragg-Grating Surface-Emitting Laser

Advantages would include lower threshold current, smaller size, and increased efficiency.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed semiconductor laser would emit radiation perpendicularly to its broad surface by use of an annular Bragg grating as the output coupler. The proposed laser is expected to produce a narrow output beam and, in comparison with a conventional surface-emitting semiconductor laser grating, is expected to be smaller, to have lower threshold current, and to be more efficient.

In a conventional surface-emitting semiconductor laser grating, a second-order Bragg grating of straight, parallel lines is positioned at one or both end(s), of a long, straight gain region (see Figure 1). This gain region, or laser stripe, must be wide to obtain a narrow output beam. Furthermore, it must be longer than it is wide to prevent cross-lasing. As a result, the gain region is fairly large and has a correspondingly high threshold current.

The proposed semiconductor laser would have a multi-quantum-well structure with a microcavity defined in part by the Bragg surface grating (see Figure 2). Instead of attempting to make the light in the gain region move in a parallel beam toward a straight output grating, the gain region would be shortened and narrowed to a small circle, from which the light would be allowed to spread out radially to the annular output grating.

The scaling-down of the gain region would increase the laser gain. The use of the multiple-quantum-well active region should make it possible to achieve the required gain, even while increasing the required pump-current density.

The grating would not be extended underneath the narrow stripe of metal leading to the circular contact above the gain region or on the opposite side of the contact. This feature would favor oscillation in the first-order mode rather than in the zeroth-order mode. The first-order mode has a null under the narrow contact stripe, and consequently there would be little or no undesired absorption from the stripe.

This work was done by Robert J. Lang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 47 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17912.

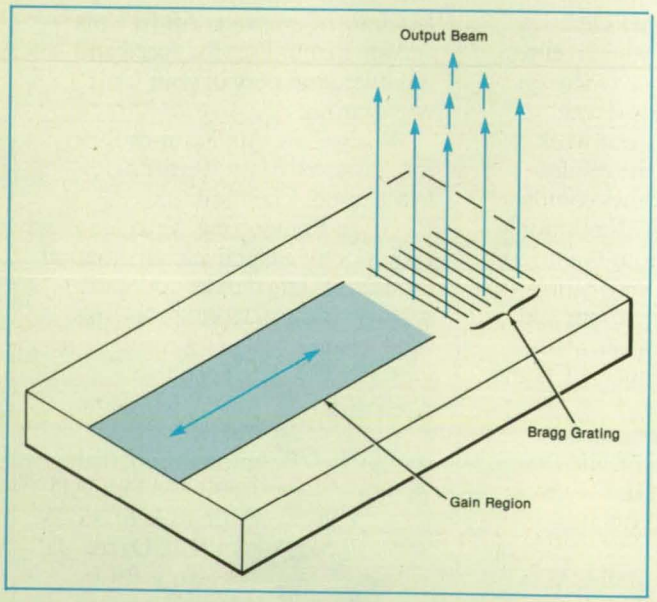

Figure 1. A **Conventional Grating Surface-Emitting Semiconductor Laser** has a relatively long, wide gain region and an output Bragg grating of straight, parallel lines.

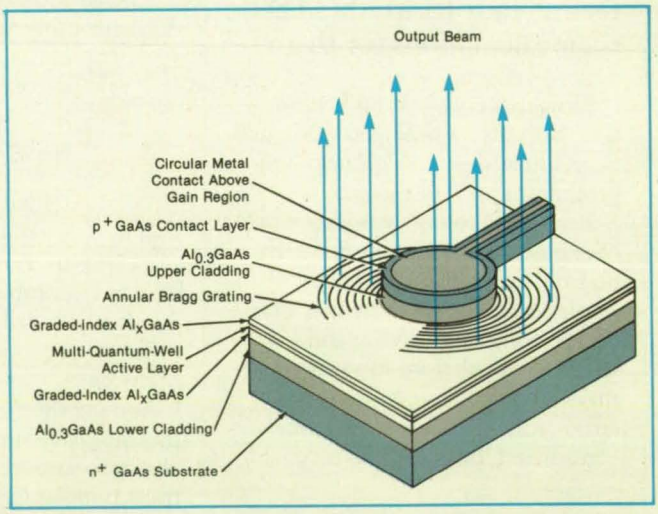

Figure 2. The **Proposed Grating Surface-Emitting Semiconductor Laser** would have a small, circular gain region surrounded by an annular Bragg grating.

Unstable-Resonator Distributed-Bragg-Reflector Laser

Semiconductor laser stripes could be made wider for higher power.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed distributed-Bragg-reflector (DBR) semiconductor laser would have wide curved gratings that would favor single-mode operation, even with a relatively wide laser stripe. The use of a wider stripe would enable the use of higher power.

A DBR laser consists of a semiconductor double heterostructure laser bounded

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at each end by a region of passive waveguide. A Bragg grating with a spatial period equal to half the wavelength of the laser light is etched on the surface of each waveguide end. These Bragg gratings act as feedback reflectors. Some of the light traveling within the waveguide is diffracted back along the waveguide, providing feedback for laser operation.

A conventional DBR laser has a straight plane parallel grating (upper part of figure) which acts as a highly-frequency-selective planar mirror. If the laser stripe is made wider than about 10 μm, it becomes unstable, oscillating in multiple lateral electromagnetic modes. Because such modes degrade the far-field pattern of the output beam and because straight gratings have poor discrimination among such modes, conventional DBR lasers have been made with narrow laser stripes.

The proposed DBR semiconductor laser (lower part of figure) would have a wide laser stripe and first-order gratings that would curve away from the stripe, with typical radii of the order of 1 cm. The gratings would act as highly-frequency-selective curved mirrors, the equivalent curvatures of which would be such that the device would operate as an unstable resonator. Such resonators are known to discriminate strongly among lateral modes in macroscopic lasers and have been demonstrated to yield stable field patterns in semiconductor lasers with etched mirrors. The curved grating would improve single-mode behavior. In addition, it should be possible to adjust the reflectivities of the mirrors by tailoring the depths of the gratings across the device.

This work was done by Robert J. Lang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 46 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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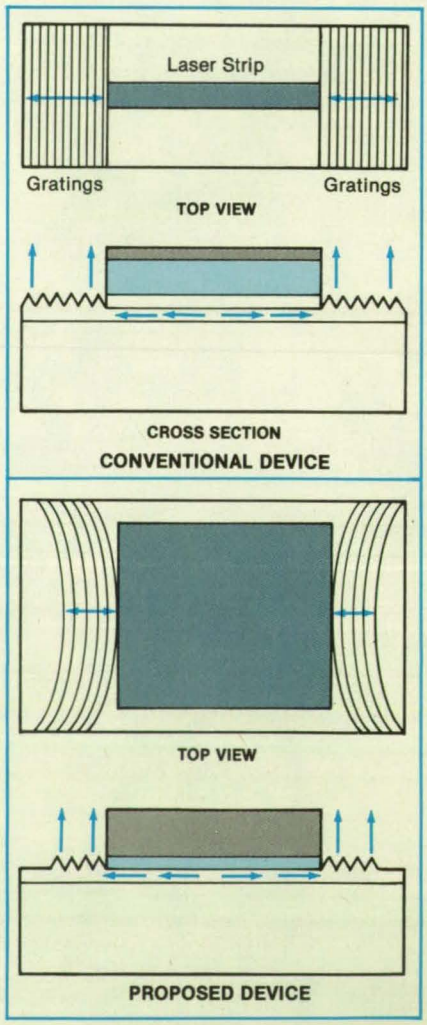
Refer to NPO-17906, volume and number of this NASA Tech Briefs *issue, and the page number.*



Conventional and Proposed DBR Semiconductor Lasers have straight and curved gratings, respectively. The conventional device has to have a narrow laser stripe to operate in a single lateral mode. The proposed device would have a wide laser stripe, yet would operate in a single longitudinal and single lateral mode.

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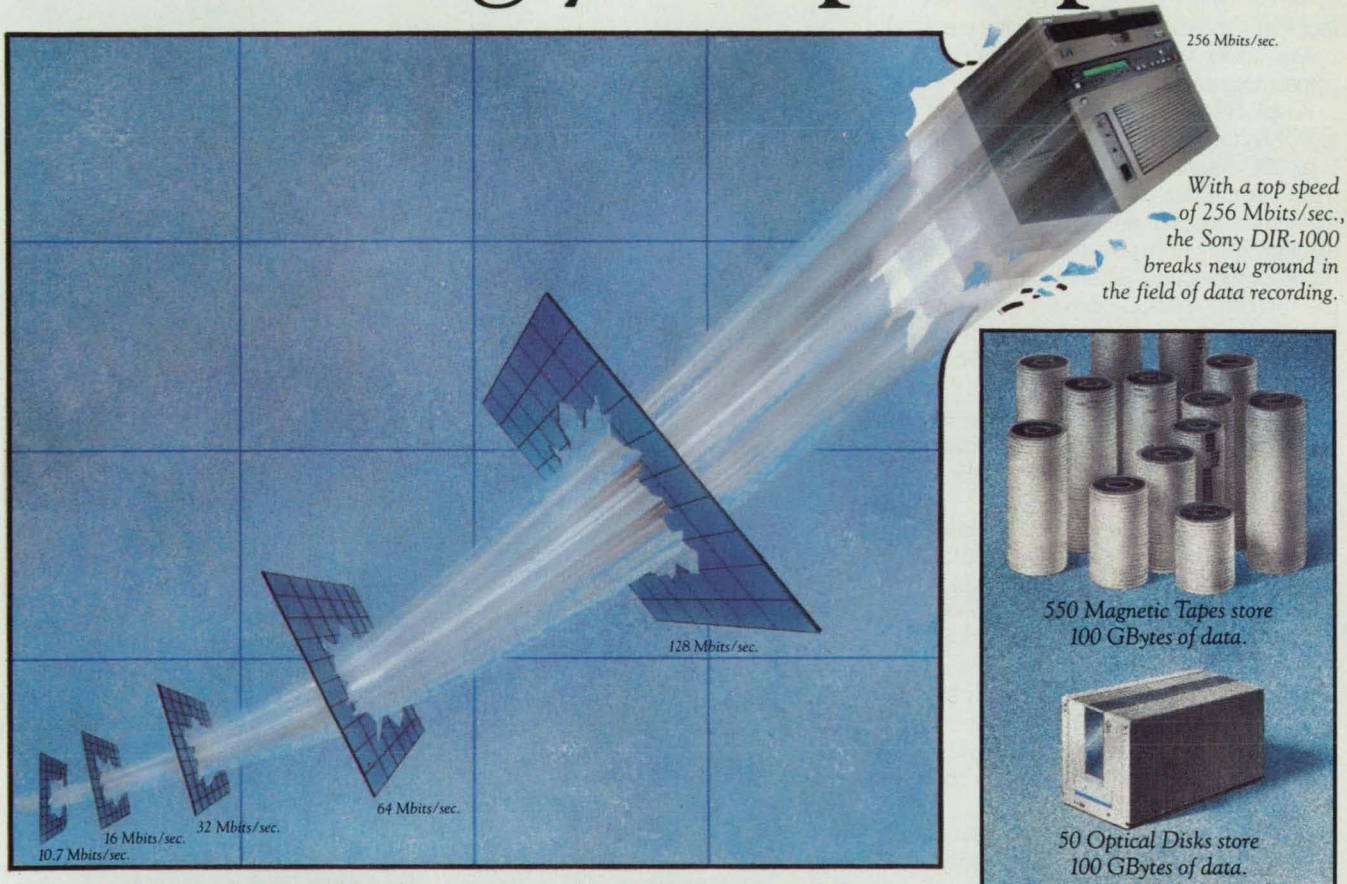

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Antireduction Insulator for Solid-Electrolyte Cell

The depletion of oxygen from the electrolyte would be prevented.

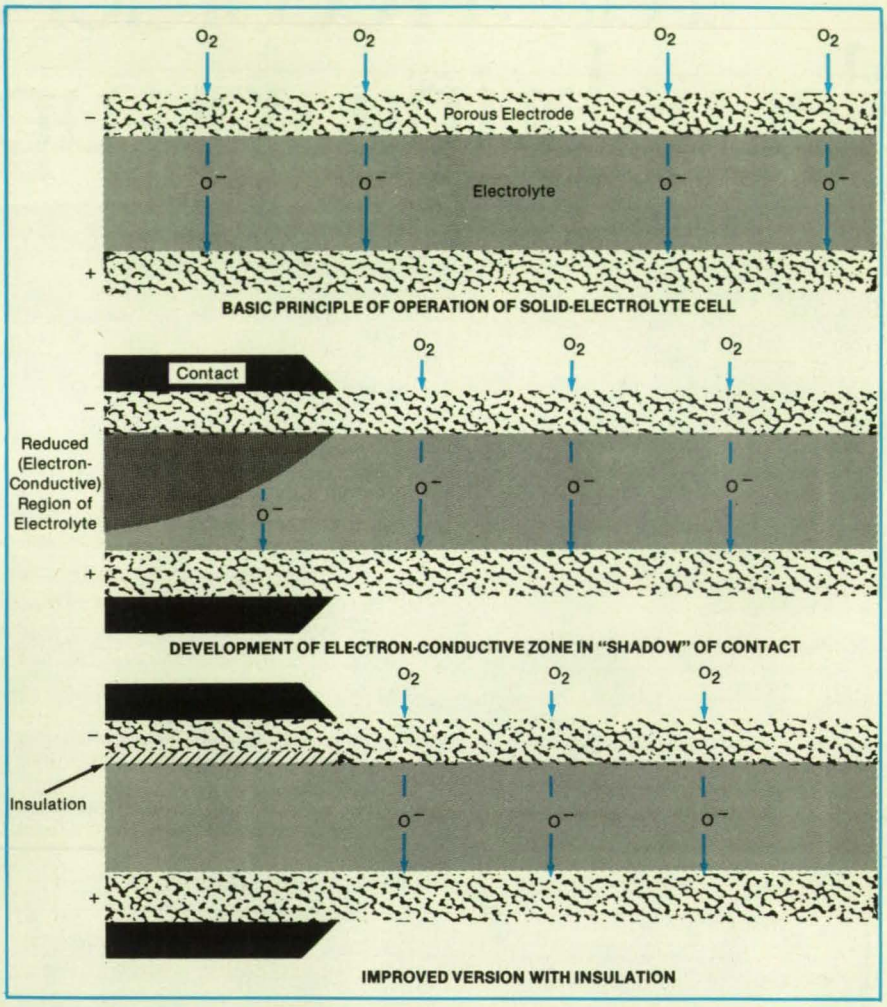
NASA's Jet Propulsion Laboratory, Pasadena, California

It has been proposed to add a layer of electrical insulation between the solid electrolyte and the portion of the porous negative electrode under the negative metal contact in a solid-electrolyte cell. The insulation would help to maintain the efficiency of the cell by preventing the "shadow" effect that degrades the portion of the electrolyte under the negative contact and sometimes near seals.

A typical solid-state electrolytic cell (see top of figure) includes a solid electrolyte (e.g., ZrO_2) sandwiched between porous metal electrodes (e.g., Pt sponge). The electrodes are permeable by gas, and the electrolyte is permeable by O^- ions but not by O_2 molecules. When a voltage is applied across the cell, O^- ions are formed at the negative electrode, then migrate across the electrolyte to the positive electrode where they are neutralized back into O_2. Thus, the cell acts as a pump for oxygen. Such a cell could also be used as an oxygen-pressure sensor or as a fuel cell to generate electricity.

For maximum efficiency, all of the electrical conduction of the cell should be in the transport of ions. To the degree to which the electrolyte exhibits electronic or hole conduction, the cell loses efficiency through increased resistive heating and partial or total diversion of the current through the nonionic short circuit. This can occur where, for example, the ZrO_2 electrolyte is reduced to ZrO_{2-x}, which is a strong conductor of electrons.

In a region of the cell under the negative electrode where the electrolyte is "shadowed" by a contact, seal, or other material impermeable by gas, O^- ions can still migrate from and through the electrolyte to the positive electrode, but O_2 gas cannot diffuse readily into the electrolyte to replenish the O^- ions lost from the electrolyte. Thus, the affected portion of the electrolyte is partly reduced to ZrO_{2-x}, becoming a conductor of electrons (see middle of figure). If the region of depletion grows until it touches the positive electrode, it short-circuits the electrolyte, drastically reducing the flow of oxygen.



The **Solid-Electrolyte Cell** is depicted in aspects of its design and operation.

In the proposed version of the cell (see bottom of figure), the insulation would suppress electrical current in the contact "shadow," so that ions would not migrate out of the shadow. Even if the electrolyte in the shadow were to become a conductor of electrons by reaction with the contact metal or by some other process, the insulation would also block the resulting electronic conduction. In making the proposed cell, the layer of insulation would be deposited by masked evaporation, sputtering, or another well-known technique. The insulation could be alumina, silica, or a refractory insulating ceramic.

This work was done by Paul J. Shlichta of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 30 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL *[see page 18].* *Refer to NPO-17211.*

Binary Operation of a Liquid-Crystal Light Valve

Operating conditions that provide increased contrast have been discovered.

NASA's Jet Propulsion Laboratory, Pasadena, California

Conditions for the operation of a commercially available liquid-crystal light valve as a binary spatial light modulator have been discovered. In this mode, the modulator turns on sharply and then saturates as the intensity of the writing beam increases. Potential applications include the enhancement of images, optical recording, and holography.

The light valve comprises a photoconductive layer and a liquid-crystal layer that are separated by a dielectric mirror and sandwiched between two transparent electrodes. The liquid-crystal molecules have a 45° twist in going from one side of the cell

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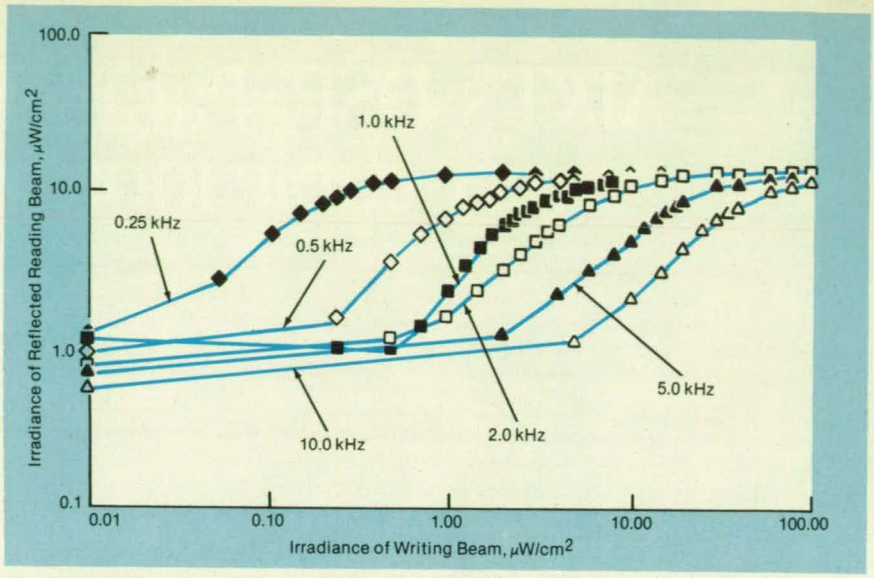
to the other. The orientation of the molecules at the faces is maintained by grooves scribed on the materials at the boundaries of the liquid-crystal layer.

The photoconductor and liquid-crystal layers act as a voltage-divider network. When no light falls on the photoconductor, its resistance is high, so that when an ac voltage is applied across the entire package, the greater fraction of the voltage appears across the photoconductor. Wherever the writing beam illuminates the photoconductor, its electrical resistivity decreases, allowing a greater fraction of the applied voltage to appear across the liquid-crystal layer in the illuminated regions. The increased voltage across the liquid-crystal layer changes the twist and tilt of the liquid-crystal molecules, altering the birefringent properties of the layer. A polarized reading beam incident on the liquid-crystal layer is reflected back by the dielectric mirror. The polarization of the reflected beam depends on the state of the liquid crystal. The reflected beam is analyzed by a polarizer. The reflected beam can be separated from the incident reading beam either by using beam splitters or by operating at a nonnormal angle of incidence.

In experiments, the writing beam was obtained by filtering the output of an air-cooled argon laser to select the 514.5-nm-wavelength output. A helium/neon laser produced the reading beam. High contrast was achieved with writing-beam intensities that ranged from $\lesssim 0.4$ to $\gtrsim 4$ $\mu W/cm^2$ at a 1-kHz bias of 7.07 Vrms. Operating parameters that were altered to optimize performance for use as a binary modulator include the frequency and amplitude of the ac bias voltage and the orientations of the polarizers in the reading beam.



The **Transfer Function of the Liquid-Crystal Light Valve** shifts as the frequency of the ac bias voltage is changed. The maximum slope occurs at a bias frequency of 1 kHz.

The family of curves in the figure shows how the intensity of the reflected light in the experiments varied as the frequency of the bais voltage was varied in the vicinity of the optimum operating point for use as a binary modulator. For each curve, the angle of the analyzing polarizer was adjusted to maximize reflectivity at a writing intensity of 100 $\mu W/cm^2$. It is expected that the optimum operating parameters will differ somewhat from one modulator to another. However the qualitative features should be similar.

This work was done by Jeffrey A. Davis of San Diego State University Foundation for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 31 on the TSP Request Card.* NPO-17614

High-Voltage Square-Wave Generator

Pulse rise times of the order of 50 ns are routine.

NASA's Jet Propulsion Laboratory, Pasadena, California

A fast switching circuit puts out rectangular pulses of the order of a kilovolt or greater at typical repetition frequencies as high as hundreds of kilohertz and with rise times as short as 50 ns. The circuit is designed around power metal oxide/semiconductor field-effect transistors (MOSFET's) that are capable of blocking potentials up to 1,000 V. The design overcomes the limitations on switching speeds imposed by the combination of junction capacitances and collector resistors in bipolar-transistor switching circuits. The switching circuit could be used, for example, to supply power to a pulsed laser or to modulate a beam of charged particles in a laboratory experiment or industrial process.

The circuit (see figure) features two power MOSFET's on the high-voltage side, optically isolated from the low-voltage side. The controlling input waveform from a low-voltage (typically, 5 V for transistor/transistor logic) pulse generator is fed through a circuit that adjusts the phase, if necessary for the specific application. A Schmitt trigger cleans up any noise on the signal and directs the waveform to the NAND gates, which drive the light-emitting diodes (LED's) of the optoisolators. When a NAND output goes low, current passes through and activates the associated LED, turning on the associated power MOSFET switch. The transistor-switch side of the optoisolators, and everything else from there to the final output floats on the high voltages that are used in forming the final wavetrain.

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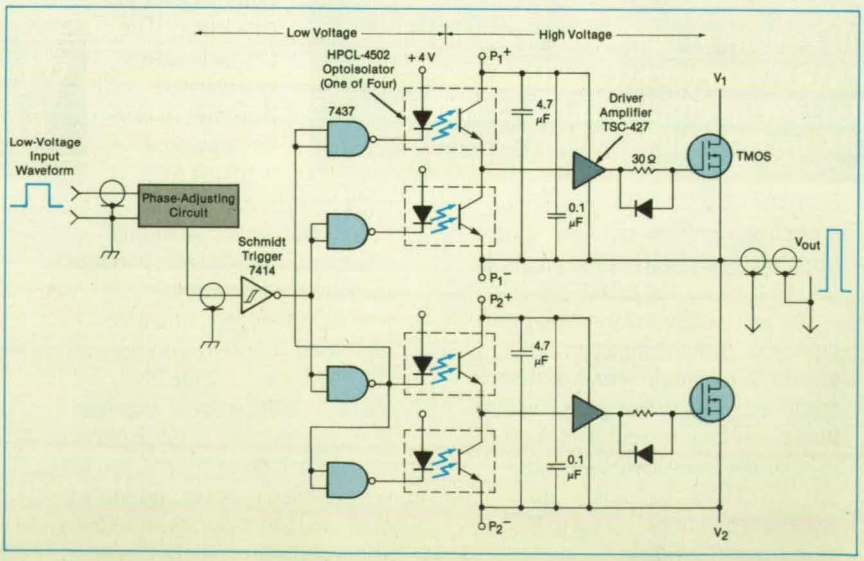

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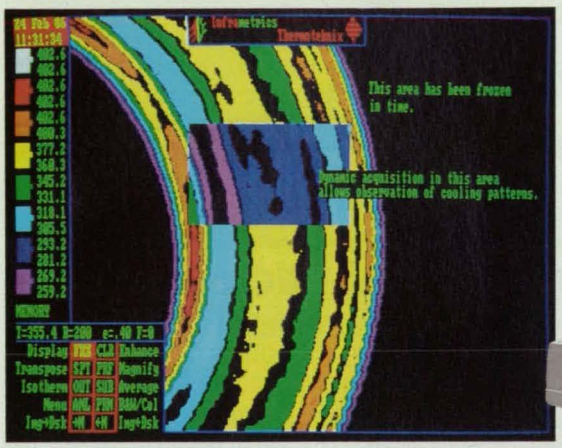

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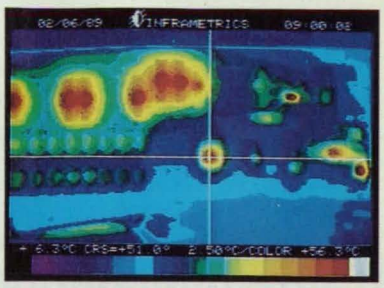

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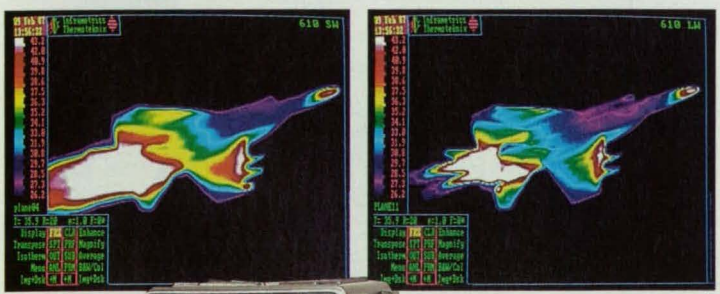

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supply floats on the source line of its associated power MOSFET. Each 12-Vdc card supplies power to its optoisolator switch and to an integrated-circuit noninverting driver amplifier capable of charging 1,000 pF in 30 ns. This amplifier promotes high switching speed by rapidly charging the gate capacitance of its associated power MOSFET. To guarantee low supply impedance over a wide frequency range, a tantalum capacitor in parallel with a ceramic capacitor is used to bypass the supply to the driver.

The optoisolator switches in each pair are arranged in series "totem-pole" configuration to switch the driver amplifier between the source line, *S*, of the associated power MOSFET and *S* + 12 volts. The two power MOSFET's are also configured in "totem-pole" fashion to drive the output load between V_1 and V_2, the high voltages used in the final wavetrain. The "totem-pole" network enables the n-channel MOSFET's to switch between arbitrarily chosen, variable voltages, as long as $V_1 > V_2$. (V_2 can be negative.)

This work was done by Mark T. Bernius and Ara Chutjian of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 121 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17772

Current-Monitoring and -Limiting Circuit for 28-Vdc Supply

This circuit acts as a limiter, monitoring amplifier, and delayed-action circuit breaker.

Goddard Space Flight Center, Greenbelt, Maryland

A current-monitoring and -limiting circuit protects a 28-Vdc power supply against a steady overload. In addition, it provides some protection against sudden peak currents — especially the large inrush current that would otherwise occur when a dc-to-dc converter or other load containing a capacitance is suddenly connected to the power supply via a manual or mechanical relay switch. It is desirable to suppress large inrush currents because they can cause electromagnetic interference in other circuits and can stress the switch contacts.

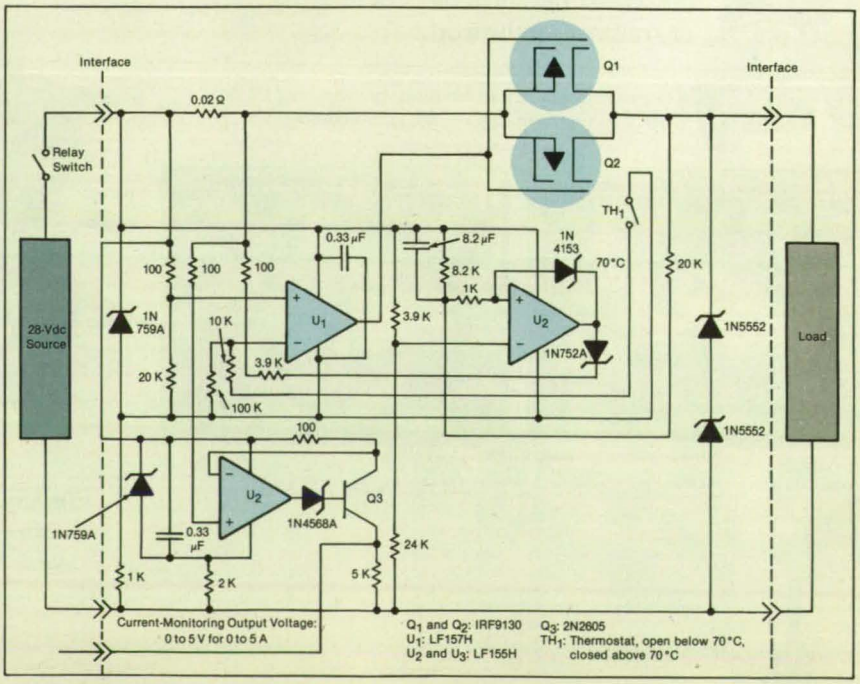
The current-limiting element in this circuit consists of a pair of power metal oxide/semiconductor field-effect transistors (MOSFET's). The development of such devices has progressed to a stage at which they are attractive for use in inrush-current-suppressing applications. By taking advantage of their low "on" resistances and their low required drive powers, one can obtain a circuit that has low insertion resistance and that limits current to the load. To limit the current by use of conventional bipolar transistors, one would have to provide for standby power to ensure the saturation of such transistors to maintain a low voltage drop across them. The use of the MOSFET's in this circuit reduces the required standby power. Furthermore, the MOSFET's chosen for this circuit are of the p-channel type, which are easy to bias.

As shown in the figure, the two p-channel power MOSFET's, Q_1 and Q_2, are connected in parallel to handle the desired maximum current of 3 A. A small precise wirewound resistor of 0.02 Ω is used to sense the current for both the control and the monitoring functions. The current-sensing voltage developed across this resistor is sensed by the operational amplifier U_1 and compared with a reference voltage developed by the voltage divider of 100 Ω and 20 kΩ across zener diode 1N759A. If the current-sensing voltage equals or exceeds the reference voltage, the drive to Q_1 and Q_2 is reduced until the current-sensing voltage equals the reference voltage. This condition of equality corresponds to a load current of approximately 3 A.

When the current is less than the 3-A maximum, Q_1 and Q_2 are biased "on" and present a low insertion resistance between the source and the load. Because Q_1 and Q_2 dissipate considerable power in the current-limiting mode, either they have to be mounted on a heat sink capable of dissipating this power, or they must be turned "off" when a predetermined safe operating temperature is reached. For this purpose, the temperature of Q_1 and Q_2 is assumed to be that of the heat sink and is sensed by thermostat TH_1 mounted on the heat sink. TH_1 is set to switch, when the temperature rises above 70 °C, to alter the voltage applied to the inverting input of U_1 in such a way as to cause Q_1 and Q_2 to turn off.

In the event the load resistance is such that the output voltage is less than approximately one-half of the input voltage, the circuit behaves as a circuit breaker that has a fixed delay. For this purpose, the voltage across Q_1 and Q_2 is sensed by operational amplifier U_2, which is configured as a comparator. The delay makes it possible to charge a capacitance of reasonable size in or across the load without turning "off" prematurely. The voltage across the 0.02-Ω resistor is also sensed by operational amplifier U_3 and transferred with reference to the common return via transistor Q_3 and the collector resistor of 5 kΩ, giving a current-indicating output potential that ranges from 0 to 5 V when the current ranges from 0 to 5 A.

This work was done by G. Ernest Rodriguez of **Goddard Space Flight Center**. *No further documentation is available. GSC-13310*

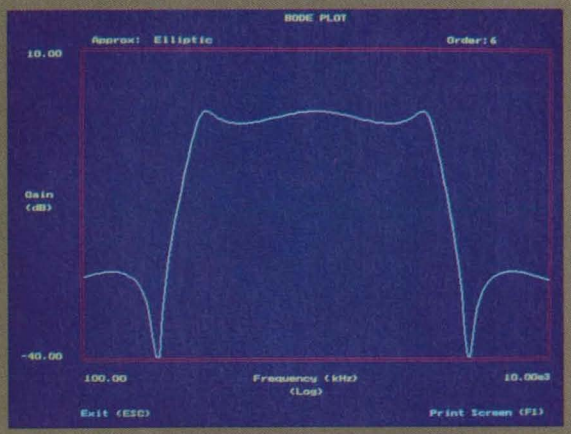


The **Current-Monitoring and -Limiting Circuit** limits the steady load current to 3 Adc, provides delayed protection against overloads, and puts out a current-monitoring voltage signal.

PSpice

MicroSim Corporation

The Standard for Circuit Simulation Has Expanded



Advanced Filter Designer Bode Plot

Advanced Filter Designer: *New* Front End Design Tool

The PSpice family of products includes both the Circuit Analysis and Circuit Synthesis packages. The Circuit Analysis package contains our PSpice circuit simulator and its options, and the Circuit Synthesis package contains our filter synthesis products, Advanced Filter Designer and Standard Filter Designer.

Advanced Filter Designer is an interactive design aid giving you the ability to design and analyze active filters. Features include a menu-driven interface, hard copy report summaries and plots, cascading multiple designs, and interfaces to PSpice and SWITCAP.

Advanced Filter Designer uses a well established methodology in applying classical approximations to your filter specification. Available filter types include low pass, high pass, band pass, and band reject, all of which may be synthesized by Butterworth, Chebyshev, Inverse Chebyshev, and Elliptic (Cauer) functions. There is also the capability to synthesize arbitrary fransfer functions and delay equalization filters.

A full editing capability allows you to insert, delete, and reorder stages, and modify coefficient values. These editing features allow a filter expert to fine tune a design, or quickly make a small modification to an existing design.

Advanced Filter Designer supports both active RC and switched-capacitor biquad filter structures. The components may be scaled or resized to center the values in preferred ranges.

Both Bode and pole-zero plots are available. Normally, you can determine the acceptability of your design by the inspection of its Bode plot. The Advanced Filter Designer plots gain, phase, and delay vs. frequency. For sampled data designs, you can plot your choice of the *s*- or *z*-domain transfer function. Pole-zero plots allow you to inspect the roots of the transfer function in either the *s*-domain or *z*-domain.

Filter Designer works with our PSpice circuit simulation package. PSpice and its options form an integrated package for the analysis of electronic and electrical circuits.

Each copy of our Circuit Analysis and Circuit Synthesis programs comes with our extensive product support. Our technical staff has over 150 years of experience in CAD/CAE, and our software is supported by the engineers who wrote it.

For further information about our Circuit Analysis or Circuit Synthesis packages, please call us at (714) 770-3022 or toll free (800) 245-3022.

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Circle Reader Action No. 320

Low-Inductance Wiring for Parallel Switching Transistors

Transistors share current equally, without sacrifice of switching speed.

Marshall Space Flight Center, Alabama

A simple configuration for the wiring of multiple parallel-connected switching transistors minimizes the stray wiring inductance while providing for the use of balancing transformers, which equalize the currents in these transistors. The balancing of currents is necessary to prevent overloads in individual transistors, and the minimization of inductance is essential for fast switching of high currents. High-current transistor switches that could benefit from the new configuration are found in controllers for brushless motors, dc-to-dc voltage converters, controllers for electric furnaces, remote controllers for dc power, high-power pulse generators, and driving circuits for traction motors.

Interleaving and multifilar windings can reduce the leakage inductances of transformers to acceptable levels. Previously,

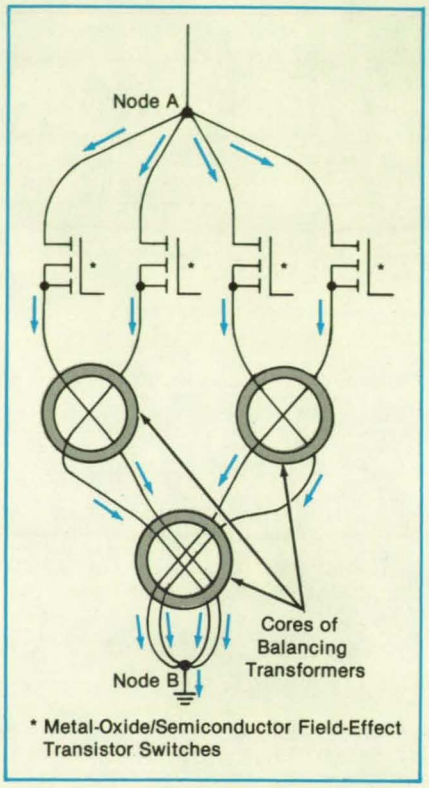


Figure 1. In the **Old Wiring Configuration**, currents are balanced on single wires, with return current running elsewhere. This configuration has relatively high inductance.

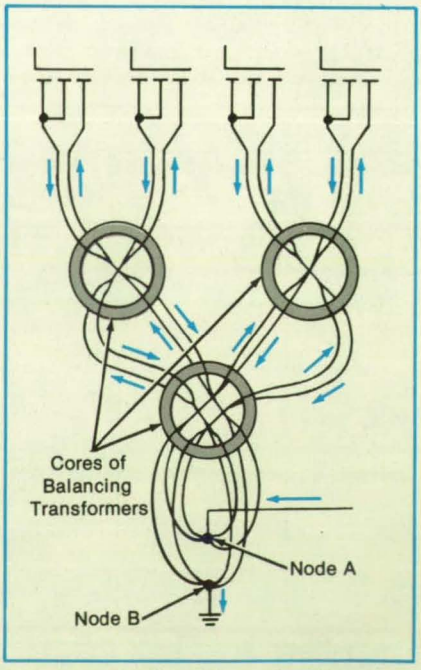


Figure 2. In the **New Wiring Configuration**, currents are balanced on twisted pairs of wires. Because the twisted pairs carry both the "hot-side" and return currents, this configuration has relatively low inductance.

however, the use of balancing transformers entailed excessive distributed wiring inductances because the connections to the transistors were made with relatively-high-inductance single wires (see Figure 1).

The new configuration (see Figure 2) is based on the established technique of reducing of inductance by laying wires in twisted pairs. The source and drain leads of each transistor are connected to six twisted pairs of wires. (To enhance clarity, Figure 2 shows only one pair, untwisted, connected to each transistor.) The twisted pairs from all the transistors are woven through the cores of the balancing transformers in a way that produces opposing magnetic fluxes, which minimize both the net inductance and the imbalances of currents.

This work was done by M. S. Veatch and D. M. Landis of Martin Marietta Corp. for **Marshall Space Flight Center**. *For further information, Circle 43 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18]. Refer to MFS-28387.

Two-Way Optical Data Link on One Fiber

Dual-purpose LED's reduce cost.

NASA's Jet Propulsion Laboratory, Pasadena, California

An optoelectronic terminal for digital communication both transmits and receives over a single optical fiber. It uses the same semiconductor device — a light-emitting diode (LED) — as both the transmitting and receiving transducer.

A data link that consists of two such terminals communicating via an optical fiber is half-duplex; it does not carry messages in opposite directions simultaneously but rather in time-shared fashion: messages are alternately transmitted or received by each terminal, but transmitting and receiving modes of a terminal cannot operate simultaneously. Although the maximum possible data rate is only half that of a two-fiber, full-duplex link, the cost of the single-fiber link could be much lower.

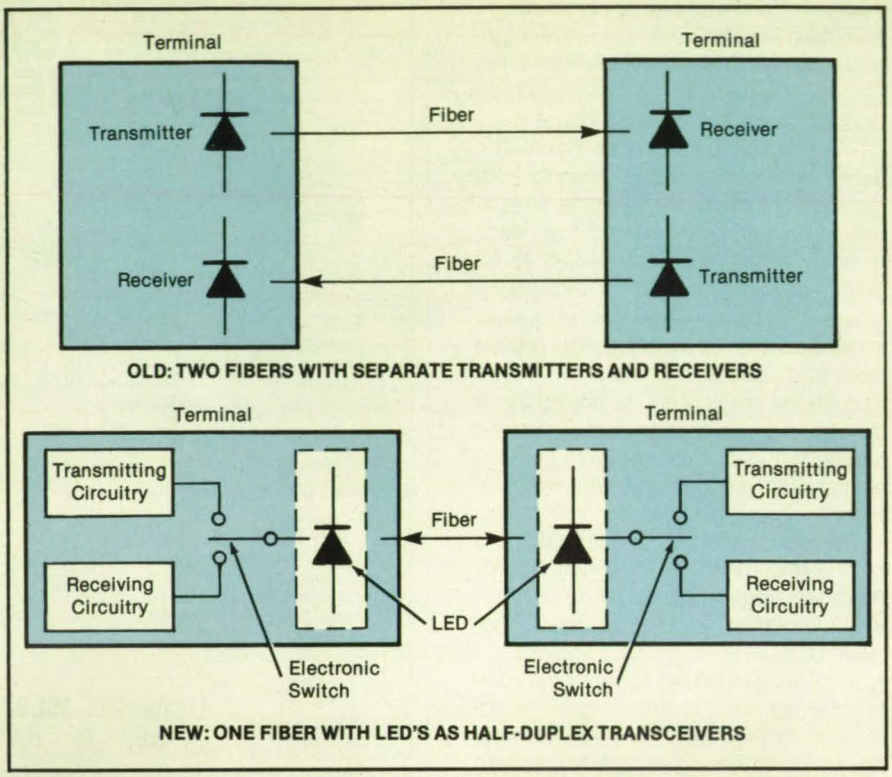
Ordinarily, PIN photodiodes are used as receivers, and semiconductor lasers or LED's are used as transmitters in optical-fiber links. The possibility of using a LED as a receiver is mentioned in at least one introductory electronics text and was found to be practical. Reasonably high data rates

are possible if the proper type of LED is selected, and optical-to-electrical conversin efficiency — ordinarily quite low for LED's — can be made acceptably high with the help of suitable electronic circuitry.

The use of a LED as a transmitter and receiver saves the cost of a separate receiving element at each end of the link. It also avoids the considerable cost and an unavoidable optical loss of 6 dB of an optical power splitter at each end to separate the transmitted and received beams of light. Each terminal includes a solid-state switch that switches the LED between the transmitting and receiving modes (see figure).

A laser can also be used as a transmitter/receiver. However, lasers cost much more than LED's do, and are useful in high performance links where a combination of high data rate (≳5Mbit/s) and distance (≳1km) are needed.

This work was done by Harold Kirkham, Alan R. Johnston, Shannon P. Jackson, and Heather A. Friend of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 52 on the TSP Request Card.*
NPO-17884



A **Single Module** alternately transmits and receives along a single two-way optical fiber. A switch alternately connects the light-emitting diode to transmitting and receiving circuitry. In contrast, a standard two-fiber, two-way link uses separate devices for receiving and transmitting.


• Tap Into The Latest NASA Technology
• Meet Top Government/Industry R&D Experts
• Find Innovative Ideas For New Products
TECHNOLOGY 2000
the first national conference and exhibition
of NASA's technology for transfer
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November 27-28, 1990

- ❖ access technology from NASA and its contractors
- ❖ meet government/industry tech transfer experts
- ❖ find new partners for R&D ventures
- ❖ discover the latest innovations in a variety of high-tech fields
- ❖ explore future applications of space-based research

A Gold Mine Of Technology Awaits You

Designed to bolster U.S. competitiveness in the global marketplace, **TECHNOLOGY 2000** is the first national conference and exhibition of NASA technology and technology transfer. NASA programs of the past three decades have created a vast storehouse of technology that is available *now* for use by industry in developing new products and processes. **TECHNOLOGY 2000 will show you how to tap into this multi-billion dollar resource to improve your productivity and gain a competitive edge.**

In two action-packed days, government and industry trailblazers will bring you up to speed on the latest innovations in computer technology, electronics, materials, biomedicine, and other key fields -- with a focus on potential commercial applications. Between and after these sessions visit the idea-stocked exhibit hall and meet experts from all nine NASA field centers as well as many of the top high-tech companies and universities nationwide.

TECHNOLOGY 2000 presents a unique opportunity to interact with these leaders, to develop contacts with potential R&D partners, and to discover what's directly ahead in a variety of high-tech fields.

Thousands of firms have picked up NASA's ideas and run with them, creating successful new products. Others have used space-based technology to hone their internal operations or improve their manufacturing systems. You too can benefit from this wealth of government-sponsored research. Join NASA, its major contractors, and other high-tech companies at **TECHNOLOGY 2000**, November 27-28, 1990.

Explore The Cutting Edge

The **TECHNOLOGY 2000** program will feature over 100 presentations by top NASA researchers and industry leaders in the following areas:

- ❖ Artificial Intelligence
- ❖ Computer Technology and Software Engineering
- ❖ Environmental Science
- ❖ Human Factors Engineering and Life Sciences
- ❖ Information and Data Management
- ❖ Manufacturing and Fabrication Technology
- ❖ Materials Science
- ❖ Optics and Communications
- ❖ Power, Energy, and Control Systems
- ❖ Robotics
- ❖ Sensors and Measurement Technology
- ❖ Superconductivity

TECHNOLOGY 2000

P R O G R A M

Tuesday, November 27

Plenary Session I

8:30 a.m. - 11:00 a.m.

8:30 - ***Keynote Address: Vice President Dan Quayle*** (invited)
9:00 - ***A View To The Future***
Senior NASA administrators will define three of NASA's primary missions:
❖ The Space Exploration Initiative (SEI), which will establish a permanent lunar base and then extend man's presence beyond Earth orbit to Mars;
❖ The Mission To Planet Earth Program, which will use an array of orbiting platforms to study global changes in an effort to understand global warming and other environmental problems;
❖ The National Aero-Space Plane (NASP) Program, which will strengthen U.S. leadership in civil and military aviation by developing a vehicle that can take off from a runway like an ordinary jet, climb into space or fly intercontinental "hops" at up to 25 times the speed of sound, and then land on a runway.
Presenters will focus on the technical achievements needed to meet the mission objectives of these programs.
Special emphasis will be placed on technical innovations that will be available for commercialization in the near future, including advances in structures, high-temperature materials, robotics, systems reliability, sensors, computers, high data rate management, large-scale modeling, and cryogenics.

Concurrent Technical Sessions

2:30 p.m. - 5:30 p.m.

Session A

Computer Technology and Software Engineering (Part 1)

The Virtual Environment Display System

Dr. Michael McGreevy, James Humphries and Warren Robinett, Aerospace Human Factors Research Div.; Ames Research Center
Ames scientists have developed a head-mounted, wide-angle, stereoscopic display system that enables the user to explore a 360-degree "virtual" environment and viscerally interact with its components. System configuration, applications, and research directions will be described.

Virtual Acoustics Displays

Dr. Elizabeth Wenzel, Research Psychologist; Ames Research Center
Dr. Wenzel will describe an innovative signal processing device capable of generating externalized, three-dimensional sound cues for headphone presentations in real time. Applications involve any context in which the user's spatial awareness is important, particularly when visual cues are limited or absent. Examples include air traffic control displays, advanced teleconferencing, telerobot monitoring, and scientific "visualization" of multi-dimensional data.

FAST: A Multi-Processed Environment For Visualization Of Computational Fluid Dynamics

Gordon Bancroft, Fergus Merritt, Todd Plessel, Paul Kelaita, R. Kevin McCabe and Al Globus; Sterling Federal Systems Inc.
This presentation will spotlight the Flow Analysis Software Toolkit (FAST), a software system for visualization and analysis of complex fluid flows. Developed by Sterling under contract to NASA's Ames Center, FAST handles a diverse range of problems, is extensible, and can be adapted to new software and hardware configurations through the use of modular structured programming methods, a graphics library standard, and common network communication protocols (such as UNIX sockets) for the distribution of processing.

Hypercube Technology

Presenter to be determined
The MARKIII hypercube supercomputer designed at Jet Propulsion Laboratory (JPL) has been successfully applied to a broad problem set including electromagnetic scattering, discreet event simulation, plasma transport, matrix algorithms, neural network simulation, image processing, and graphics. Currently, problems that are not homogeneous are being attempted, and through these "real world" applications the software is evolving to efficiently handle heterogenous class problems.

The Hyperswitch Communication Network

Presenter to be determined
JPL researchers have developed a high-speed, fault-tolerant communication architecture based on the Hyperswitch chipset for use in the next generation of hypercube supercomputers. This architecture reduces overall message reception latency by two to three orders of magnitude and has a data transmission bandwidth thirty times greater than that of existing hypercube computers.

Biological Neural Networks As Model Systems For Designing Future Parallel Processing Computers

Dr. Muriel Ross, Research Scientist; Ames Research Center
Biological neural networks are highly successful computational systems which function as massively parallel, distributed processors of information. Dr. Ross' research team is studying the three-dimensional organization of a simple biological neural network found in inner ear organs of balance (vestibular maculas) to uncover the fundamental principles of neural organization, and to understand the relationship between neural organization and functioning through modeling. The findings will have applications in computer technologies and robotics.

Session B

Human Factors Engineering and Life Sciences (Part 1)

Biomedical Applications Of NASA Technology

Donald Friedman, Chief, Office of Commercial Programs, Goddard Space Flight Center; and Dr. Russell Eberhart, program manager, Biomedical Programs, Johns Hopkins University Applied Physics Laboratory
An array of technologies that promise new solutions to biomedical problems will be described, including the Programmable Implantable Medication System, which offers a way to free insulin-dependent diabetics from daily injections; the Biomedical Implantable Thermal System, capable of accurately measuring and relaying deep internal body temperatures; and the Implantable Functional Electrical Stimulation System, which aims to improve paralyzed functions. The presenters will also cover biomedical applications of neural networks and the use of astronomy technology to detect glaucoma.

Direction-Discriminating Hearing Aid System

Dr. Murzy Jhabvala, Chief Engineer, Instrument Microelectronics and Detectors Branch; Goddard Space Flight Center
Individuals who suffer a severe hearing loss in one ear have difficulty discerning the direction from which sounds originate. A basic approach to solving this problem is to detect sound from two directionally-oriented microphones mounted on the user. Sounds are then amplified and compared; the stronger signal is shown on a visual display which notifies the user of the direction from which the received sound emanated. The electronic portion of the system is based on a custom-developed CMOS integrated circuit.

X-Ray Imaging Microscope For Cancer Research

Richard Hoover, Astrophysicist, Space Science Laboratory; Marshall Space Flight Center
This presentation will focus on the design of the Water Window Imaging X-Ray Microscope, configured to operate within a narrow regime of the x-ray spectrum that lies between the K absorption edges of oxygen and carbon. In this "water window," carbon is highly absorptive and water is highly transmissive. Therefore, the microscope should be able to delineate -- with high spatial resolution and contrast -- carbon-based structures within living cells. It affords strategies for examining living tumor cells without the need for dyes, stains, or exogeneous chemicals that produce limiting artifacts.

Mechanical Response Tissue Analyzer For Estimating Bone Strength

Dr. Sara Arnaud, Research Scientist, Ames Research Center; Anthony Mauriello, President, Gait Scan Inc.; and Dr. Charles Steele, Professor of Applied Mechanics, Stanford University
A new instrument called the Mechanical Response Tissue Analyzer uses a low-frequency vibratory stimulus to provide a direct measure of a mechanical property of bone. It shows promise for both diagnosis of osteopenic bone disease and monitoring effects of activity or treatment on bone strength.

Adaptation Of NASA Technology For The Optimization Of Orthopedic Knee Implants

Dr. Dimitrios Saravanos and Dale Hopkins, Lewis Research Center; Dr. Dwight Davy, Chairman, Bioengineering Dept., Case Western Reserve University
NASA technology originally created to optimize composite engine blades has been adapted to produce improved knee implants. Researchers have developed a method for tailoring the implant to the environment of the tibial bone. The shape and composition of the implant components are optimized such that the stresses in the tibia are favorably controlled to minimize bone degradation and prevent failures. This innovation should provide the means for improving knee prosthesis and tailoring the implant to individual patients.

Session C

Information And Data Management

Optical Storage Device

Sharon Welch, Aerospace Technologist; Langley Research Center

This presentation will focus on a new holographic information storage device that uses four-wave mixing in two photorefractive crystals. In previous studies of holographic storage using photorefractive crystals, the information was typically stored in a single crystal. This technique has the disadvantage that once the incident object (write) beam is removed, the stored information, or holographic grating, can be read out only once before being destroyed. By using four-wave mixing in two photorefractive crystals, it is possible to store a holographic image and read out the information an infinite number of times.

Rewriteable Optical Disk Recorder

Dr. Thomas Shull, Branch Head, and Pamela Rinsland, Assistant Branch Head, Electronics Branch; Langley Research Center

A NASA program to develop a high-performance rewriteable optical disk recorder for spaceflight applications will be presented. An expandable, adaptable system concept is proposed based on disk drive modules and a modular controller. System goals are up to 160 gigabyte capacity at up to 1.8 gigabits per second rate with concurrent I/O, asynchronous data transfer, and two to five year operating life in orbit.

Monitoring And Analysis Of Data From Complex Systems

Thomas Dollman, Team Leader, Software and Data Management Division; Marshall Space Flight Center

As flight systems become more complex and longer-lived, it becomes increasingly difficult to monitor and analyze their data. One method being developed to address this problem is the use of information systems in ways that enable the engineer to relate the data to the system design more readily. Another method is to encode knowledge about the system's operation into the computer system itself, to serve as a backup to the engineer's analysis and conclusions. These methods, now being tested at the Marshall Center, promise to help maintain the high productivity levels of the telemetry analyst over long periods.

High Data Rate Systems For The Future

John Chitwood, Head, RF Technology Section, Microwave Instrument and RF Technology Branch; Goddard Space Flight Center

Information systems in the next century will transfer data at rates much greater than those in use today. To meet these future needs, work is under way to improve systems that operate at RF, microwave, millimeter wave, and optical frequencies. As high data rate systems employ large bandwidths, efforts have been concentrated in areas that use optical wavelengths and millimeter wave frequencies around 60 GHz. Potential applications include high-resolution multi-channel television, high-speed videotext, and large-volume data dissemination services.

Advanced X-Ray Compression Technique

Richard Galle, Technology Utilization Officer; Stennis Space Center

Electronic storage and transmission of radiological data are areas that significantly impact the medical community's everyday operations. Current data compression schemes are inefficient and result in excessive volumes of stored data. Further, much time is required to electronically transfer x-ray information to remote sites. Stennis engineers have developed a highly efficient and dependable x-ray compression scheme that has achieved compression ratios of 40:1 or greater; the compression algorithms presently in use rarely achieve ratios greater than 5:1. The technology is currently undergoing clinical trials at a highly respected medical institution and a production prototype should be available in the near future.

DAVID: The Distributed Access View Integrated Database

Dr. Barry Jacobs, Senior Research Computer Scientist; Goddard Space Flight Center

NASA is developing methodologies that will enable space scientists, managers, and system developers to universally access data over heterogeneous systems without having to learn the specific access methods of the constituent systems. The technological approach involves the development of heterogeneous access methods over several classes of data: databases, spreadsheets, manuscripts, images, graphics, maps, audiovisuals, indexes, serials, kits, books, experts, and objects. NASA's end goal is to transfer the technology to the private sector using Small Business Innovative Research (SBIR) and other funding.

Three-Dimensional Perspective Visualization

Kevin Hussey, Supervisor of the Visualization and Earth Science Applications Group; Jet Propulsion Laboratory

Mr. Hussey will describe JPL's efforts to create highly realistic computer-simulated flights over very large, remotely-sensed digital databases, through algorithm development and application of advanced computer hardware.

Session D

Materials Science (Part 1)

High-Performance Polymer Development

Paul Hergenrother, Senior Polymer Scientist; Langley Research Center

As part of an effort to develop high-performance adhesives and composite matrices for aerospace applications, NASA Langley's polymer work has focused on innovative polyimides, poly (arylene ethers), and blends of reactive monomers and oligomers with thermoplastics. Langley has developed several new polyimides that exhibit excellent adhesive, composite, and film properties at temperatures up to 232 degrees C. In the area of poly (arylene ethers), heterocyclic units such as quinoxaline, triazole, imidazole, and oxadiazole incorporated within the polymer have resulted in higher glass transition temperatures and high tensile strengths and moduli. Several blends of reactive monomers and oligomers with high-performance thermoplastics have yielded cured resins with excellent high-temperature adhesive and composite properties. The chemistry, mechanical and physical properties, and potential uses of representative polymers will be highlighted.

Industrial Applications Of Graphite Fluoride Fibers

Dr. Ching-Chee Hung, Research Physicist; Lewis Research Center

Graphite fluoride fiber is a new material whose physical properties can be tailored to meet the requirements of various engineering designs. Properly-processed graphite fluoride, for example, can be a thermally-conductive insulator. It therefore could be used as a heat sinking printed circuit board material that keeps the board's densely-packed circuits from overheating. Further, its coefficient of thermal expansion (CTE) could be tailored such that its composite is CTE-compatible with silicon. By using such a composite as printed circuit board material, the cracks of the tiny solder joints between the silicon chip's pins and the boards at high temperatures due to CTE mismatch could be avoided.

Fluoroepoxy Compounds As Adhesives For Fluoroplastics

Dr. S. Yen Lee, Materials Branch; Goddard Space Flight Center

Fluoroepoxy compounds are made by reacting a fluoroepoxy resin with a curing agent such as an adduct amine. While the compound is sufficiently liquid to wet a fluoroplastic surface, it can be applied to a fluoroplastic adherend, such as Teflon, to be employed as an adhesive in the formation of bonds and various fluoroplastic products. No surface treatment is required. Another application involves the creation of fluropolymer foams with controllable amounts of inert-gas fillings in the foam cells. Unlike thermoplastic fluoropolymers, the thermosetting fluoropolymers do not require foaming additives that leave undesirable residues and can be formed at relatively low pressures and temperatures. Potential applications include coatings, electrical insulation, and wire products such as coaxial cables and power lines.

Dual Beam Process Diamond-Like Films For Industrial Applications

Michael Mirtich, Bruce Banks, and James Sovey, Lewis Research Center; Michael Kussmaul, Sverdrup Technology

A unique dual ion beam system developed by these scientists enables low-temperature deposition of diamond-like carbon coatings on plastics, quartz, silicon, metals, and a variety of other materials. The patented process can be used to coat relatively large objects and produces films with high electrical resistivity, extreme hardness and clarity, and chemical inertness -- making them well suited for optics and electronics applications.

Plasma-Polymerized Coating For Polycarbonate: Single-Layer, Abrasion-Resistant, And Antireflective

Dr. T. Wydeven, Research Scientist; Ames Research Center

Dr. Wydeven developed a process for depositing plasma-polymerized vinyltrimethoxy silane films on transparent polycarbonate substrates. The adherent, clear films protect the substrates from abrasion and also serve as antireflection coatings. Post-treatment of the films in an oxygen glow improves the abrasion resistance. The patented process is currently used by the world's largest manufacturer of non-prescription sunglasses to protect the plastic lenses from scratching.

The PM200 Lubrication System

Harold Sliney, Senior Scientist, Lewis Research Center; and William Waters, TU Materials Consultant, Waters & Associates

Several years ago, Harold Sliney developed PS200, an award-winning high-temperature lubricant which is plasma-sprayed onto bearings and seals. Current plasma spray processes cannot be used, however, for small parts such as bushings. PM200 contains the same constituents as PS200, but is designed to form small parts using powder metallurgy processes, and therefore offers an increased range of applications.

Session E

Manufacturing And Fabrication Technology

Robotics In Space-Age Manufacturing

Chip Jones, Metals Processes Branch; Marshall Space Flight Center

The Marshall Center is developing robotics technologies to improve manufacturing of space hardware. This presentation will cover applications such as robotic welding for the space shuttle and space station Freedom programs; manipulation of high-pressure water for shuttle solid rocket booster refurbishment; automating the application of insulation materials; precision application of sealants; and automation of inspection procedures. Commercial robots are used for these development programs, but they are teamed with advanced sensors, process controls, and computer simulation to form highly productive manufacturing systems. Many of the technologies are being actively pursued for use in private sector manufacturing operations.

Variable Polarity Plasma Arc Welding

Ernest Bayless, Branch Chief, Metals Processes Branch; Marshall Space Flight Center

The Variable Polarity Plasma Arc (VPPA) welding process was developed at the Marshall Center for manufacture of the space shuttle aluminum alloy external tank. This unique computer-controlled

welding process significantly improves the weldability of aluminum alloys by eliminating internal defects and reducing thermal distortion as well as preweld cleaning and joint preparation requirments. The VPPA is currently being adapted for applications on the advanced solid rocket motor (ASRM) high-strength steel material and the space shuttle main engine (SSME) nickelbased alloys. Further enhancements to the process will include sensor control of seam tracking, weld beam profiling, and wire feed entry control.

High-Pressure Water Jet Cutting And Stripping

David Hopp, Aerospace Technologist, Tooling Applications Branch; Marshall Space Flight Center
High-pressure water jet cutting techniques have a wide range of applications to the American space effort. Hydroblasting techniques are used, for example, during refurbishment of the space shuttle's solid rocket motors. The process can be controlled to strip a thermal protective ablator without damaging the painted surface underneath by employing a nozzle which rotates at 1500 rpm and discharges water under 15,000 psi pressure. This is a slow and costly operation, however, and is extremely hazardous. Marshall researchers have automated the process using a computer-controlled robot mounted on a transportable platform. The six-degree-of-freedom robot can be used to reach almost any position quickly and efficiently; an operation which requires an hour manually can be performed in 20 minutes. The robotic system has already saved millions of dollars and hours of processing time during refurbishment of solid rocket motors at Kennedy Space Center.

Cost-Efficient Manufacturing Of Composite Structures

W. Tom Freeman, Aerospace Technologist, and Dr. John Davis, Head of the Structures Technology Program Office; Langley Research Center
In the Advanced Composites Technology (ACT) program, NASA is seeking research breakthroughs that will allow structures made of epoxy-type resins to replace metal in the wings and bodies of future aircraft. The agency's goals are to reduce acquisition cost by 20-25 percent, structural weight by 40-50 percent, and the number of individual parts by half compared to current production aluminum aircraft. This presentation will focus on the innovative structural concepts, materials, and fabrication techniques emerging from the ACT program, and will discuss the relationship between aerospace developments and industrial, commercial, and sporting goods applications.

Rapid Induction Bonding Of Composites, Plastics, And Metals

Dr. John Buckley, Materials Research Engineer, Fabrication Division; Langley Research Center
Langley researchers have created a rapid electromagnetic induction bonding system that joins composites, plastics, metals, and combinations of these materials. The equipment is self-contained, portable, and uses only 100-400 watts. It allows heat to be directly applied to the bond lines and/or the adherends without heating the entire structure, supports, and fixtures of a bonding assembly. Bonding times for laboratory specimens have been cut by a factor of 10 to 100 compared to standard press or autoclave bonding.

Reliability And Risk Assessment Of Structures

Dr. Christos Chamis, Senior Aerospace Scientist, Lewis Research Center; and Dr. Michael-Chu-Yu Shiao, Research Scientist, Sverdrup Technology Inc.
Many structures that require high performance, reliability, and durability operate under complex environments including random excitations and temperatures. These excitation and temperature variations not only degrade the material but also cause an additional randomness in the uncertain material behavior. To account for the aforementioned problems, a methodology was developed at NASA Lewis for a probabilistic structural analysis applicable to a wide variety of structures. The presenters will describe this methodology, which consists of a probabilistic structural analysis by a specialty computer code NESSUS (Numerical Evaluation of Stochastic Structures Under Stress), a generic probabilistic material property model, and a probabilistic fatigue analysis. The structural reliability and associated risk obtained by this methodology are useful in evaluating the traditional design, setting, quality control, and inspection requirements, and for certifying to authorities the assured safety and useful life of the structural systems.

A Semi-Automated Process For The Production Of Custom-Made Shoes

Dr. Franklin Farmer, Manager of Biomedical Application Projects; Langley Research Center
More than one-half million Americans require custom-made shoes. These shoes are extremely expensive because their design and manufacture is a highly-skilled and labor-intensive process. The costs could be reduced by using a CAD/CAM process based primarily on NASA-developed software programs such as NASCAD and APT. Dr. Farmer will describe the process and demonstrate its products.

Lightweight, Fire-Retardant, Crashworthy Aircraft Seat Cushioning

Dr. Leonard Haslim, Program Manager, Advanced Plans and Programs Office; Ames Research Center
Dr. Haslim has designed an innovative seat cushion that offers a comfortable, lightweight, cost-efficient alternative to the polyurethane foam cushions presently used in aircraft, automobiles, and many types of home furniture. These cushions support combustion and pose a toxic gas hazard when exposed to fire. Dr. Haslim's improved model employs a fire-blocking configuration of self-extinguishing materials that produces virtually no hazardous fumes.

Session F

Power, Energy, And Control Systems

Civil Air Transport: A Fresh look At Power-By-Wire And Fly-By-Light

Gale Sundberg, Deputy Chief, Electrical Components and Systems Branch; Lewis Research Center
Power-by-wire (PBW) is a key element under subsonic transport flight systems technology with potential savings of over ten percent in gross takeoff weight and fuel consumption compared to today's transport aircraft. PBW technology substitutes electrical actuation in place of centralized hydraulics, uses internal starter-motor/generators, and eliminates the need for variable engine bleed air to supply cabin comfort. The application of advanced fiber optics to the electrical power system controls, to built-in-test equipment, and to fly-by-light flight controls provides additional benefits in lightning and high energy radio frequency immunity over existing mechanical controls. This presentation will give a snapshot of the key technologies and their benefits to all future aircraft.

The Free-Piston Stirling Engine -- From Space Technology To Terrestrial Applications

James Dudenhoefer, Chief, Stirling Technology Branch; Lewis Research Center
The Stirling engine is a candidate high-capacity dynamic power source for space systems in the late 1990s and into the next century. Space power requirements include high efficiency, very long life, high reliability, and low vibration. The free-piston Stirling has the potential to be a highly reliable engine with long operating life because it has only a few moving parts, noncontacting gas bearings, and can be hermetically sealed. These attributes also make it a viable candidate for terrestrial applications. Industry teams are currently completing designs for two advanced Stirling conversion systems utilizing technology developed under NASA's Civil Space Technology Initiative program.

Solar-Powered Stirling Cycle Electricity Generator

Richard Shaltens, Senior Project Manager; Lewis Research Center
The 25 kW free-piston Stirling cycle electricity generator developed for space use is being combined with a parabolic mirror solar heat concentrator to produce an economical solar-powered electricity generator for terrestrial applications. Such units could be used for "topping" power cycles by utilities, especially in the Sunbelt. They also offer tremendous potential in the Third World, much of which lies in tropical areas with lots of available sunshine. Mr. Shaltens will describe current development efforts and possible application areas.

Four Quadrant Control Of Induction Motors

Irving Hansen, Research Engineer; Lewis Research Center
Induction motors are our workhorse, being the motor of choice in most applications due to their simple rugged construction. It has been estimated that the country's electricity use could be reduced by 14-27 percent by incorporating adjustable speed drives. Until now, however, induction motors have not been suited for variable speed or servo drives due to the inherent complexity, size, and inefficiency of their variable speed controls. Work at NASA Lewis on field-oriented control of induction motors using a pulse population modulation method holds promise for the desired drive electronics. The system allows for a variable voltage of frequency ratio, which enables the user to operate the motor at maximum efficiency while having independent control of its speed and torque in all four quadrants of the speed torque map.

Bi-Polar Battery Technology

Dr. Gerald Halpert, Technical Group Supervisor, Battery Systems Group; Jet Propulsion Laboratory
Dr. Halpert will explain how advances in increasing the energy storage capability of high-power lead-acid batteries have paved the way for their potential use in previously unattractive applications such as electric-powered vehicles.

New CCD Technologies At JPL

James Janesick, Member of Technical Staff; Jet Propulsion Laboratory
Mr. Janesick will describe recent work on charge-coupled devices (CCDs) which has resulted in unprecedented performance in the areas of read noise, charge collection efficiency, charge transfer efficiency, and quantum efficiency. Further, these technologies have enabled the fabrication of ultra-large CCDs (4096 x 4096 pixels).

Advanced Thermal Technology For Commercial Applications

Ted Swanson, Senior Engineer, Thermal Engineering Branch; *Goddard Space Flight Center*
Future space facilities such as space station Freedom and a lunar base will require advanced thermal control technologies. One promising concept is the capillary pumped thermal transport loop, or CPL, which is similar to a heat pipe in that it can transport large quantities of heat over long distances with negligible temperature drop. The CPL, however, offers a two-order-of-magnitude improvement over current heat pipe technology. Mr. Swanson will discuss CPL development efforts and potential spinoff applications.

Session G

Robotics

ROBOSIM, A Simulator For Robotic Systems

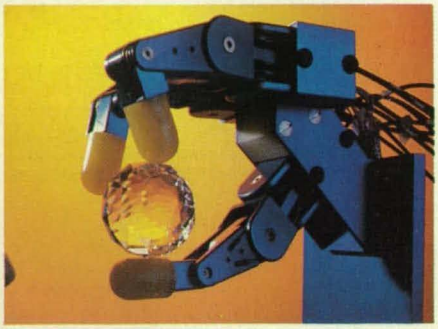
Dr. Ken Fernandez, Software and Data Management; Marshall Space Flight Center
ROBOSIM was created by NASA to aid in the rapid prototyping of automation. It has enabled the development of improved robotic systems concepts for both Earth-based and proposed on-orbit applications while significantly reducing development costs. ROBOSIM has been adapted for use in the classroom as a safe and cost-effective way to allow

students to study robotic systems. Dr. Fernandez will provide an update on new application areas, improvements made to the simulator's design, and efforts under way to ensure the timely dissemination of this technology.

Control System Software, Simulation And Robotic Applications

Harry Frisch, Head, Robotics Applied Research Section; Goddard Space Flight Center

Goddard has developed multibody dynamics programs which can be used to create dynamics simulation models of any system. The system can be modeled as a collection of hinge-connected rigid bodies acted upon by both internal and external loads. During the past decade, these programs have been used for an extremely broad range of problems and have proven to be the only logical method for reducing the cost of in-depth analysis. Mr. Frisch will describe several applications of this technology, including muscle dynamics modeling in support of eye movement research; modeling and simulation of neural prosthesis; study of gait for the handicapped; and comparison of operational options, man versus robot.



Discover the latest advances in telerobotics.

Telerobotic Electronic Materials Processing Experiment

Stanford Ollendorf, Chief, Office of Telerobotic Engineering; Goddard Space Flight Center

Mr. Ollendorf will describe an experiment designed to investigate the potential for developing in--space facilities for the automated production of microelectronic devices. An experiment will be flown in which a telerobot will transport samples of solar cell materials between stations where the material can be stored, processed, and/or analyzed. Processes will include various types of thin film deposition and annealing which relate to the production and reconditioning of solar cells.

Advanced Mechanisms For Robotics

John Vranish, Aerospace Electrical Engineer, Electromechanical Branch; Goddard Space Flight Center

Recent robotics work at Goddard has focused on end effectors and related mechanisms, robot-friendly payload latching mechanisms, compliant joints, and collision avoidance/management skin for robotic arms. Mr. Vranish will detail significant developments in these areas and their commercial potential.

The Flight Telerobotic Servicer And Technology Transfer

James Andary, FTS Systems Manager, FTS/Development Test Flight Project; Goddard Space Flight Center

The Flight Telerobotic Servicer (FTS) will help astronauts build and maintain space station Freedom, thereby reducing crew extravehicular activity requirements. The highly dexterous robot will combine teleoperation -- the use of a human operator to direct the machine -- and autonomous capabilities for performing tasks on its own but under an astronaut's supervision. This presentation will focus on present FTS research in areas such as advanced computer vision and autonomous planning, the technologies that will result from this research, and potential terrestrial applications.

FARMS: The Flexible Agricultural Robotics Manipulator System

Paul Gill, Electrical Aerospace Engineer; Marshall Space Flight Center

Marshall and the University of Georgia have jointly developed a robotic end effector for the processing of live plant material. The robotic device is designed to improve efficiency and productivity in commercial nurseries and green house systems, and could be applied to future space projects such as manned space stations and planetary communities requiring large-scale food production.

Diverse Applications Of Advanced Man-Telerobot Interfaces

Douglas McAffee, Member of Technical Staff; Jet Propulsion Laboratory

Advances in man-machine interfaces and control technologies used in space telerobotics have potential application wherever human operators need to manipulate multidimensional spatial relationships. Mr. McAffee will explain how bilateral six-degree-of-freedom position and force cues exchanged between the user and a complex system can broaden and improve the effectiveness and intuitiveness of several diverse man-machine interfaces.

Session H

Sensors And Measurement Technology (Part 1)

Urodynamic Pressure Sensor

Thomas Moore, Aerospace Engineering Technician; Langley Research Center

A need for measuring the simultaneous, circumferential closing forces along the entire active length of the female urethra has been recognized in order to significantly improve diagnostic capabilities for the treatment of pathological anomalies in this organ. A sensor system providing six simultaneous measurements -- one in the bladder and five at discrete locations within the urethra -- has been developed in response to this need. By integrating a microcomputer into the system, one can perform analysis functions such as data smoothing, peak pressure arrival time, and muscle recovery times.

Electron Tunnel Sensor Technology

William Kaiser, Thomas Kenny, and Steven Waltman; Jet Propulsion Laboratory

The presenters will discuss development of monolithic silicon electron tunnel sensors that combine high performance, low cost, low power consumption, compact volume, and array compatibility. This technology is expected to provide a new approach for the implementation of sensors for acceleration, force, radiation, acoustic signals, and other applications.

Practical Approaches For The Application Of Resistance-Type Strain Gages On High-Temperature Composites

Thomas Moore, Langley Research Center

Installation of strain gages on any surface subjected to temperatures above 315 degrees C requires innovative techniques and appropriate gaging materials. High-temperature metal matrix and carbon-carbon composites requiring strain measurements of 815 degrees C and higher make the application of strain gages even more difficult. Mr. Moore will describe several approaches for obtaining reliable strain data on high-temperature composites for both field and laboratory test scenarios.

Space Shuttle Engine Plume Measurements

Richard Eskridge and W.T. Powers, Aerospace Technologists, Propulsion Systems Division; Marshall Space Flight Center

The Marshall Center has developed several new instruments to diagnose shuttle main engine exit plane conditions, including an Optical Plume Anomaly Detector, an Exit Plane Spectrometer, an Infrared Emission/Absorption Temperature Profiling System, a Laser Schlieren Shock/Imaging System, and a dedicated spectrometer for resonance line absorption measurements. These systems will provide valuable data on the instantaneous plume species emissions for health monitoring and will profile the temperature and species number densities for water and trace alkali metals in the engine plume.

AI Mass Spectrometers For Shuttle Health Monitoring

J. David Collins, Chief, Instrumentation Section, Kennedy Space Center

The Kennedy Space Center uses mass spectrometers to detect fuel leaks in the space shuttle main engines. These systems are very complex and require large amounts of time for maintenance and validation. Artificial intelligence (AI) programs currently being developed for real-time system health checks will reduce maintenance/validation time and allow operators to concentrate on the critical leak detection data.

Instrumentation For Optical Ocean Remote Sensing

Dr. Wayne Esaias, Oceanographer, Oceans and Ice Branch; and Fran Stetina, Aerospace Technical Manager, Laboratory for Hydrospheric Processes; Goddard Space Flight Center

Instruments used in ocean color remote sensing algorithm development, validation, and data acquisition suitable for commercial development and marketing will be discussed.

Wednesday, November 28

Concurrent Technical Sessions

8:30 a.m. - 11:00 a.m.

Session A

Artificial Intelligence

Intelligent Computer-Aided Training And Tutoring

Robert Savely, Chief, Software Technology Branch, Johnson Space Center; and Dr. R. Bowen Loftin, Professor, University of Houston

Long-duration space shuttle missions, space station Freedom, and future lunar/Mars missions will require the creation of simulation-based training systems for crew, flight controllers, and ground-based support personnel. The application of artificial intelligence technology to simulation training will allow individu-

alized training to be delivered to large numbers of personnel in a distributed workstation environment. Intelligent Computer-Aided Training (ICAT) systems simulate the behavior of an experienced instructor observing a trainee, responding to requests for help, diagnosing and remedying trainee errors, and proposing challenging new training scenarios. The general architecture for ICAT systems will be presented, and the design and evaluation of specific ICAT applications will be discussed in detail. In addition, the transfer of ICAT technology to the educational sector will be covered within the context of the Intelligent Physics Tutor Project.

CLIPS: A Tool For The Development And Delivery Of Expert Systems

Gary Riley, Computer Engineer, Software Technology Branch; Johnson Space Center

CLIPS is a forward chaining rule-based language developed at NASA Johnson that provides a complete environment for the construction of rule-based expert systems. It is designed for high portability, low cost, and easy integration with external systems. Other key features include a powerful rule syntax, an interactive development environment, extensibility, documentation, and source code availability.

Distributed, Cooperating Knowledge-Based Systems

Walter Truszkowski, Head, Automation Technology Section; Goddard Space Flight Center

Mr. Truszkowski will address the development and application of distributed, cooperating knowledge-based systems in the spacecraft ground operations environment. Because of the increasing size, complexity, and cost of planned systems, conventional procedural approaches to the architecture of automated systems will give way to a more comprehensive knowledge-based approach. A hallmark of these future systems will be the integration of multiple knowledge-based agents which "understand" the operational goals of the system and cooperate with one another and the humans in the loop. Current work includes the development of a formal model of cooperating knowledge-based agents; the creation of a reference model for knowledge base management; the establishment of an object-oriented model of an intelligent end-to-end (spacecraft to user) system; and the use of a test bed for prototyping and evaluating various knowledge-based concepts.

Electronic Neural Network Technology

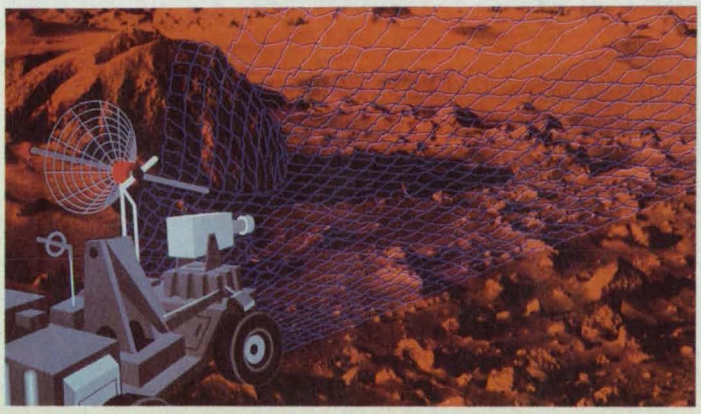
Dr. Anil Thakoor, Technical Group Supervisor, Neuroprocessing and Analog Computing Devices; Jet Propulsion Laboratory

Derived from biological neural network models, electronic neural network technology promises powerful, high-speed computing alternatives for a variety of complex, ill-defined, and fuzzy tasks not easily accomplished by conventional AI and digital techniques. Dr. Thakoor will discuss the state of neural network hardware technology and current work at JPL.

Intelligent Vision System For Autonomous Vehicle Operations

Dr. Maria Scholl, Member of Technical Staff; Jet Propulsion Laboratory

Dr. Scholl will describe the application of advanced optical correlator technology to develop intelligent vision sensors for autonomous operation of complex mobile systems.



Session B

Computer Technology and Software Engineering (Part 2)

Software Reengineering

Ernest Fridge, Deputy Chief, Software Technology Branch; Johnson Space Center

Today's software systems generally use obsolete technology, are not integrated properly with other software systems, and are difficult to maintain. The discipline of reverse engineering is becoming prominent as organizations try to move their systems up to more modern and maintainable technology. The Johnson Center created a significant set of tools to develop and maintain FORTRAN and C code during development of the space shuttle; this tool set forms the basis for an integrated environment to reengineer existing code into modern software engineering structures which are then easier to maintain and which allow a fairly straightforward translation into other target languages. The environment will support these structures and practices even in areas where the language definition and compilers do not enforce good software engineering.

Transportable Applications Environment (TAE) Plus: A NASA User Interface Development And Management System

Martha Szczur, TAE Project Manager, Software and Automation Systems Branch; Goddard Space Flight Center

Designed to operate on graphic workstations supporting MIT's X Window System, TAE Plus is a WYSIWYG (What You See Is What You Get) tool for designing, building, and tailoring an application's user interface (UI) and for controlling the UI throughout the application's execution. The system's main component is the WorkBench, which allows the application developer to interactively construct the layout of an application screen and manipulate a set of interaction objects (menus, buttons, icons, dials, strip charts, etc.). Ms. Szczur will describe how a developer would use the WorkBench to create an application's user interface and will discuss the software architecture. Moreover, she will summerize how TAE Plus is being used to prototype and build user interfaces for a variety of NASA and non-aerospace applications.

Applications Of Fuzzy Logic To Control And Decision Making

Robert Lea, Aerospace Engineer, Johnson Space Center; and Dr. Yashvant Jani, Senior Corporate Scientist, Lincom Corp.

Fuzzy logic technology has shown to be powerful and robust in interpreting imprecise measurements and generating appropriate control decisions for many space operations. The presenters will describe several ongoing applications projects at the Johnson Center's Software Technology Laboratory, including an intelligent sensor system to support traffic management and proximity operations around space station Freedom.

Genetic Algorithms

Lui Wang, Computer Engineer; Johnson Space Center

Genetic algorithms provide powerful techniques for optimization, search, and machine learning. Mr. Wang will describe current efforts to build a genetic algorithm tool for use in robot path planning, scheduling, and resource allocation.

Vertical Bloch Line (VBL) Memory

Presenter to be determined

The VBL memory is an improvement on magnetic bubble memories. Like bubble memories, it is nonvolatile, radiation-hard, and has no moving parts. This presentation will focus on current development efforts and potential application areas.

Session C

Environmental Technology

Physical/Chemical Closed-Loop Water Recycling

Dr. Cal Herrmann, Water Quality Specialist, Bionetics Inc.; and Dr. Ted Wydeven, Research Scientist, Ames Research Center

New computer modeling and simulation technologies are being developed at NASA Ames for the Physical/Chemical Closed-Loop Water Recycling Project. Water needs, sources, and means for recycling water are examined in terms appropriate to the water-quality requirements of a small crew during long-duration exploration missions. Recommendations are made for development of new water recycling technology and improvement of existing technology for near-term application to life support systems for humans in space. These pioneering technologies are equally applicable to water needs on Earth, in regions where extensive water recycling is required or where advanced water treatment is essential to meet EPA health standards.

Water Quality Analyzer

Warren Kelliher, Aerospace Technologist, Langley Research Center

This presentation will illustrate the design and capabilities of a new miniaturized X-ray Fluoresence Spectrometer used to analyze water quality. Developed by NASA and the EPA, the portable unit provides on-site, real-time analysis of toxic metal contamination. There are patents pending on the invention and a commercial manufacturer is being sought.

New Research On Bioregenerative Air/Water Purification Systems

Dr. Anne Johnson, Research Biologist, Stennis Space Center

Dr. Johnson will describe the Stennis Center's efforts to characterize bioregenerative mechanisms of air and water purification. Studies include utilization of vascular plants for wastewater treatment, desalinization, and heavy waste removal. Foliage plants are also being evaluated to determine their role in the removal of toxic organics from ambient air. Similarly, researchers are examining the possibility of producing food from plants and fungi within a closed system while obtaining drinking water through the process of evapotranspiration. As plants die within the wastewater treatment system, they are used for compost to grow vegetables. Thus, this technology offers the potential for air and water revitalization as well as food production using strictly biological means.

Environmental And Facilities Management System (EFMS)

Bruce Davis, Geographer, Stennis Space Center

Centered around Geographic Information System technology, the EFMS will use information gathered by remote sensing and in situ sensor systems to create a digital database for Stennis and the surrounding region. The database will aid in monitoring the environmental impact of NASA's propulsion test operations, enabling Stennis program managers to identify potential problems and make better informed decisions.

The Land Analysis System

Dr. Yun-Chi Lu, Project Manager, LAS Project; Goddard Space Flight Center

Dr. Lu will describe the Land Analysis System (LAS), an interactive software system for the analysis, display, and management of multispectral and other digital data. Available in the public domain, LAS provides 240 applications functions and utilities, a flexible user interface, complete on-line and hard-copy documentation, extensive image data-file management, reformatting, and conversion utilities.

Potential Commercial Use Of EOS Remote Sensing Products

Leslie Thompson, Senior Systems Engineer, Sensor Concepts and Development Branch; Goddard Space Flight Center

This presentation will focus on projected products that will be available at launch from Earth Observing System (EOS) instruments and will highlight potential commercial uses of EOS data after value-added processing. Specific instruments or collections of instruments could provide vital information for crop futures trading, mineral exploration, media news products, land management and planning, digital map directories, harvest forecasts, and numerous other areas.

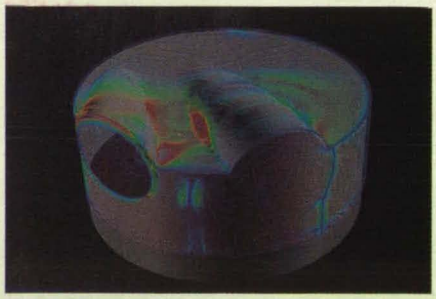
Session D

Human Factors Engineering And Life Sciences (Part 2)

Simulation Of Blood Flow Through An Artificial Heart

Dr. Stuart Rogers and Dr. Dochan Kwak, Ames Research Center; Cetin Kiris and Dr. I-Dee Chang, Stanford University

Using computational fluid dynamics (CFD) techniques first developed for the space shuttle program, scientists have created a computer model of the incompressible viscous flow through an artificial heart. The three-dimensional simulation will help medical researchers to better understand the heart's complex flow field and should lead to improved pump designs.



Three-Dimensional Structure Of Human Serum Albumin

Dr. Daniel C. Carter, Xiao-min, and Pamela Twigg, Space Sciences Laboratory; Marshall Space Flight Center

Using a technique called x-ray crystallography, researchers at NASA Marshall have uncovered the three-dimensional structure of human serum albumin, the principal protein of the circulatory system. Their discovery could lead to major advances in drug design and genetic engineering.

A Noninvasive Measure Of Minerals And Electrolytes In Tissue

Dr. Sara Arnaud, Research Scientist, Ames Research Center; and Dr. Burton Silver, Chairman of the Board and Director of Research, Intracellular Diagnostics Inc.

A novel technique that determines the concentration of ions in the rapidly regenerating cells of the mouth's sublingual area has been applied to the problem of detecting metabolic changes in astronauts during space flight. It uses x-ray microanalysis to quantify the ion concentration in cells that are obtained by scraping the surface of the oral mucosa, a noninvasive means of obtaining tissue. The technique can be adapted to monitor changes in patients with metabolic disease.

Oxygen Production Using Solid-State Zirconia Electrolyte Technology

Dr. Jerry Suitor, Technical Group Supervisor, Thermal Power Conversion Group; Jet Propulsion Laboratory

Because of its ability to conduct ionic oxygen, a solid-state zirconia electrolyte cell can separate oxygen from air and other oxygen-containing gases such as CO_2 and SO_2. Present systems can produce one liter of oxygen per minute. Dr. Suiter will discuss potential applications within the medical field, NASA, the military, and a variety of energy-intensive industries.

Monitoring And Control Technologies For Bioregenerative Life Support Systems

Dr. William Knott, Biological Sciences Officer; Kennedy Space Center

Dr. Knott will describe NASA's efforts to develop monitoring and control technologies for the various modules of a controlled ecological life support system (CELSS). Researchers are developing computer hardware and software, advanced sensors, and other technologies needed to operate biomass production and processing, food preparation, and water recycling modules.

Session E

Materials Science (Part 2)

Silicon Carbide, An Emerging High-Temperature Semiconductor

Dr. Lawrence Matus, Research Scientist, and J. Anthony Powell, Senior Research Physicist; Lewis Research Center

NASA Lewis is developing silicon carbide as a semiconducting material for operation at temperatures in excess of 600 degrees C. Research is focused on crystal growth, characterization, and device fabrication technologies necessary to produce a family of silicon carbide electronic devices and integrated electronic sensors. Aerospace applications for high-temperature electronic devices include engine ground test instrumentation, engine control and conditioning monitoring systems, and power conditioning and control systems for satellites. Industrial uses include deep-well drilling instrumentation, nuclear reactor instrumentation and control, and automotive sensors.

Meet top NASA researchers, including Dr. Daniel Carter, NASA Inventor of the Year.

Explore new developments in materials science, including advanced ceramics, plastics, and metals.

Flexible Fluoropolymer-Filled Protective Coatings

Bruce Banks, Chief, Electro-Physics Branch, and Michael Mirtich, Research Physicist; Lewis Research Center

Metal oxide films such as SiO_2 provide an effective barrier to the transport of moisture and gaseous species through polymeric films. Such thin film coatings have a tendency to crack upon flexure of the polymeric substrate. Sputter co-deposition of SiO_2 with 4%-15% fluoropolymers has been shown to produce thin films with glass-like barrier properties that have significant increases in strain-to-failure, thus improving the tolerance to flexure on polymeric substrates. Deposition techniques for producing these films are suitable for durable food packaging and oxidation/corrosion protection applications.

A Conformal Oxidation-Resistant, Plasma-Polymerized Coating

Dr. Morton Golub, Dr. Theodore Wydeven, and Dr. Narcinda Lerner, Research Scientists; Ames Research Center

In this presentation Ames scientists will report results from a comparative study of the surface recession (etching) of thin films of plasma-polymerized tetrafluoroethylene (PPTFE), ion-beam sputter-deposited polytetrafluoroethylene, and PTFE exposed to ground-state atomic oxygen [O_3P] downstream from a nonequilibrium RF O_2 plasma. A thin, conformal coating of PPTFE was found to protect an underlying reactive polymer against attack by O_3P until the PPTFE was fully etched away. A plasma-polymerized fluorocarbon coating such as the one prepared and studied in this work may be used in space to protect polymers that are sensitive to oxidation or degradation by oxygen atoms.

Flame-Retardant Composite Materials

Demetrius Kourtides, Materials Engineer; Ames Research Center

Mr. Kourtides will review the thermal and flammability properties of composites fabricated with epoxy and other thermally-stable resin matrices. Factors to be evaluated include limiting-oxygen index, smoke evolution, thermal degradation products, total-heat release, heat-release rates, mass loss, flame spread, ignition resistance, thermogravimetric analysis, and selected mechanical properties.

Superplastic Forming Of Al-Li Alloys For Lightweight, Low-Cost Structures

Stephen Hales, AS&M; and John Wagner, Materials Div., Langley Research Center

Superplastic forming (SPF) of advanced aluminum alloys is being evaluated as an approach for fabricating lightweight, high-efficiency structures at lower cost. Superplasticity is the ability of specially processed material to sustain very large forming strains without failure under controlled deformation conditions. SPF technology can be used to create complex structural parts in a single operation while reducing fabrication costs by up to 40 percent compared to conventional multiple-step forming operations. Details involved in the application of this technology to commercial aluminum-lithium alloys will be discussed.

Localized Corrosion Of High-Performance Metal Alloys In An Acid/Salt Environment

Lewis MacDowell, Materials/Corrosion Engineer; Kennedy Space Center

Various vacuum-jacketed cryogenic supply lines at the space shuttle launch site in Florida use convoluted flexible expansion joints. The atmosphere at the launch site has a very high salt content, and during a launch fuel combustion products include hydrochloric acid. This extremely corrosive environment has caused pitting corrosion failure in the thin-walled 304L stainless steel flex hoses. In this presentation, Mr. MacDowell will describe NASA's search for a more corrosion-resistant material. The search focused on 19 metal alloys which were evaluated using electrochemical corrosion testing, accelerated corrosion testing in a salt fog chamber, and long-term exposure at a beach site. As a result of this work, several nickel-based alloys were found to have very high corrosion resistance.

Session F

Optics And Communications

Digital Codec For Real-Time Processing Of Broadcast-Quality Video Signals

Mary Jo Shalkhauser, Digital Systems Engineer, and Wayne Whyte, Jr., Communications Systems Engineer; Lewis Research Center

Advances in very-large-scale integration and recent work in bandwidth-efficient digital modulation techniques have combined to make digital video processing technically feasible and potentially cost-competitive for broadcast-quality television transmission. A hardware implementation has been developed for a DPCM-based digital television bandwidth compression algorithm which processes standard NTSC composite color television signals and produces broadcast-quality video in real time at an average of 1.8 bits/pixel. The presenters will describe the data compression algorithm and the hardware implementation of the codec, and provide performance results.

Recent Advances In Coding Theory For Near-Error-Free Communications

Dr. Leslie Deutsch, Manager of Telecommunications and Data Acquisition Technology Development; Jet Propulsion Laboratory

Recent developments in the design and theory of error-correcting codes and data compression techniques have led to increased channel performance and efficiency. Also, new algorithmic techniques have made the corresponding codes easier to implement using microelectronics technology.

Microwave Integrated Circuits For Space Applications

Dr. Regis Leonard, Chief, Solid State Technology Branch; Lewis Research Center

The Lewis Center has sponsored development of a number of state-of-the-art microwave integrated circuits, principally for use in satellite communications systems but with potential application in any microwave/millimeter wave system, including radar and Earth observation systems. Chips developed include high-efficiency power amplifiers at 14, 20, 32, and 60 GHz; low-noise receivers at 32 GHz; and phase shifters at 20, 32, and 60 GHz. The chips employ advanced materials and structures such as AlGaAs HEMT and pseudomorphic HEMT to achieve high power and low noise at millimeter wave frequencies. A discussion of how such modules can be used in phased array antennas will be included.

Optical Communications For Space Missions

Dr. Michael Fitzmaurice, Assistant Chief for Communications Programs, Instrument Div.; Goddard Space Flight Center

Dr. Fitzmaurice will describe the NASA/Goddard Center program in space optical communications. NASA missions likely to benefit from this technology will be discussed and the state of the art in key subsystems will be addressed, as will potential commercial applications.

Optical Shutter Switching Matrix

Charles Grove, Chief, CCMS Engineering Section; Kennedy Space Center

A microminiature optical shutter switch has been developed for ground and space control, command, communications, and telemetric sensing systems. The optically-controlled RF switching module can directly replace existing electrical or electromechanical switches. It has the potential to replace the contents of five or six large cabinets of switching hardware with a single drawer.

Fiber Optic Tactical Local Area Network (FOTLAN)

Randall Bartman, Member of Technical Staff; Jet Propulsion Laboratory

FOTLAN is a synchronous high-speed fiber optic LAN that supports ordinary data packet traffic over a common channel. The technique can be applied to any deterministic class of data packet networks, including multi-tier backbones that must transport stream data.

High-Precision Applications Of The Global Positioning System

Dr. Stephen Lichtin, Technical Group Supervisor, Earth Orbiter Systems Group; Jet Propulsion Laboratory

The satellite-based Global Positioning System (GPS) provides users with a precise determination of position and time. GPS-based techniques can be utilized for land, sea, air, and space-related applications. In the future, it is expected that GPS or similar receiving equipment will be mass-produced and standardized, bringing the benefits of modern satellite technology to numerous individuals and businesses as well as to the scientific community.

Session G

Sensors and Measurement Technology (Part 2)

Quantitative Nondestructive Evaluation – Requirements For Tomorrow's Reliability

Dr. Joseph Heyman, Head, Nondestructive Measurement Science Branch; Langley Research Center

Quantitative Nondestructive Evaluation (QNSE) is a technology of measurement, analysis, and prediction of the state of material/structural systems for safety, reliability, and mission assurance. Dr. Heyman will highlight some of the new sciences and technologies that are part of a safer tomorrow, including thermal QNDE to aircraft structural integrity, ultrasonic QNDE to materials characterization, and technology spinoff from aerospace to the medical sector.

Robotic Inspection Verification

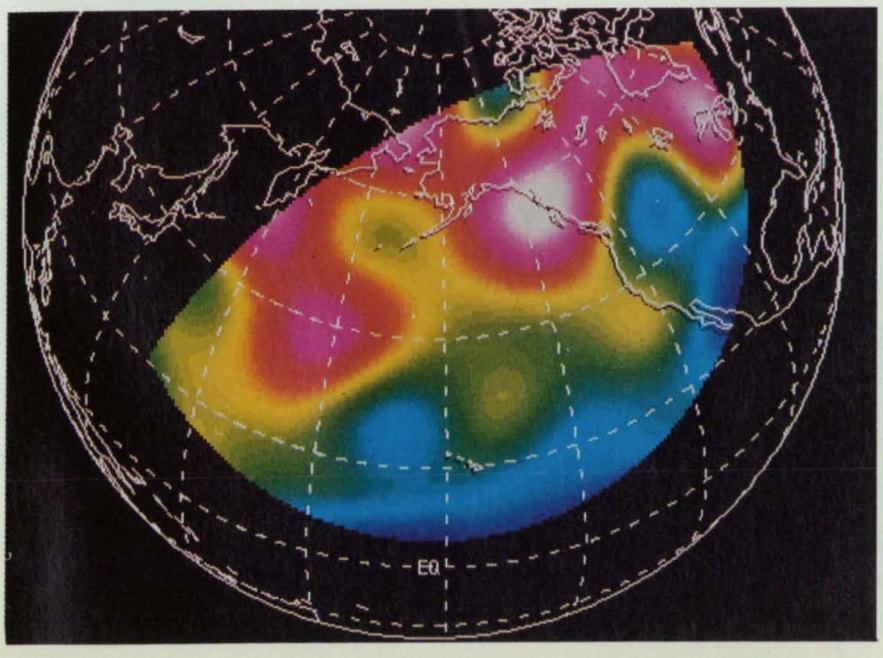
V. Leon Davis, Chief, Robotics Section; Kennedy Space Center

Kennedy researchers have developed nondestructive evaluation devices for processing the space shuttle. One is a tool used to measure the step and gap between the shuttle tiles. Another is an orbiter radiator inspection tool. Both devices are designed to be used as end effectors for robotic mechanisms. A robot is being built to transport the radiator inspection tool along the longitudinal axis of the orbiter while an optical device scans the radiators for cuts, dents, and punctures.

The Transfer Of A Technology To Measure Skin Burn Depth In Humans

Dr. William Yost and Dr. John Cantrell, Aerospace Technologists; Langley Research Center

The use of high-frequency ultrasound for nondestructive evaluation applications has led to the design and development of an instrument to measure skin burn depth. The interaction between theoretical efforts to understand the mechanisms involved in the dynamics of the burn process and the design requirements for a viable burn-depth measurement instrument will be shown as a valuable paradigm for technology transfer. The processes from inception of the idea to transfer of the instrument to a manufacturer will be traced.



NASA experts will describe commercial applications of remote sensing research.

Technology 2000 will spotlight an array of NASA spinoffs, such as an automobile engine that runs on virtually any kind of fuel.

Frequency Domain Laser Velocimeter Signal Processor

James Meyers, Electronics Engineer; Langley Research Center

Langley engineers collaborated with researchers at the Old Dominion University Research Foundation to create an innovative scheme for processing signals from laser velocimeter systems. Their invention is a "smart" digital instrument that reconfigures itself, based on the input signal characteristics, to achieve highly accurate measurements. It can solve fluid flow problems requiring a low signal-to-noise ratio, as in flare conditions associated with near surface measurements, or high accuracy, as in laminar flow measurements.

Field-Deployable Digital Acoustic Measurement System

David Gray, Head, Acoustics and Vibrations Instrumentation Section; Langley Research Center

A portable digital acoustic measurement system has been developed to support acoustic research programs at NASA Langley. The system digitizes acoustic inputs at microphones that can be placed up to 1000 feet from the van housing the acquisition, storage, and analysis equipment. Digitized data from up to 12 microphones is recorded on high-density 8mm tape and analyzed by a microcomputer system. Synchronous and non-synchronous sampling is available with maximum sample rates of 12,500 and 40,000 samples per second respectively. The high-density tape storage system can store five gigabytes of data at transfer rates up to one megabyte per second. System overall dynamic range exceeds 83 dB.

Laser Optical Disk Position Encoder With Active Heads

Eric Osborne, Aerospace Technologist, Instrument Structures Section, Electromechanical Branch; Goddard Space Flight Center

Mr. Osborne will describe an angular position encoder that minimizes the effects of eccentricity and other misalignments between the disk and read stations by employing heads with beam steering optics that actively track the disk in directions along the disk radius and normal to its surface. The device adapts features prevalent in optical disk technology towards the application of angular position sensing.

Session H

Superconductivity

Applications Of High-Temperature Superconductors

Dr. Vernon Heinen, Research Scientist; Lewis Research Center

Lewis researchers are creating high-temperature superconductors for aerospace applications, including electronics and space-based power and propulsion. Electronics applications under investigation are chiefly thin film devices for microwave systems. Among the power applications being pursued are superconducting magnetic energy storage and power transmission lines. In the propulsion area efforts are directed toward the application of high-temperature superconducting magnets to magnetoplasmadynamic thrusters, magnetic nozzles, and magnetic bearings. In support of these applications, research is under way to determine and improve the characteristics of superconducting materials in the space environment.

Superconducting Microwave Electronics At NASA Lewis

Dr. Kul Bhasin, Senior Research Scientist; Lewis Research Center

Over the last three years, NASA Lewis has investigated the application of newly-discovered high-temperature superconductors to microwave electronics. Using thin films of YBaCuO deposited on a variety of substrates -- including strontium titanate, aluminum gallate, and magnesium oxide -- a number of passive microwave circuits have been fabricated and evaluated. These include circular microstrip resonators (35 GHz), a cavity resonator (60 GHz), a microstrip filter produced in conjunction with COMSAT Laboratories, and a superconducting antenna array. Performance of these circuits will be reported as well as suggestions for other applications.

Superconductive Wires And Devices For Cryogenic Applications

Dr. John Buckley, Materials Research Engineer, Langley Research Center

Dr. Buckley will discuss methods of fabricating practical electronic circuit elements such as conductors, coils, and connectors with high-temperature ceramics by recognizing the brittle nature of these materials and designing the elements to their greatest advantage. All other known thick film technologies being developed for these materials involve ways of incorporating flexibility into the free-standing ceramic material and its various shapes. Their relative lack of success has inhibited development of actual components and devices. Dr. Buckley will describe the first practical working devices.

Melt-Processed Bulk Superconductor Fabrication And Characterization For Power And Space Applications

Dr. Arthur Thorpe, Professor of Physics; Howard University

Melt-processed bulk superconductors with large current-carrying capacity will be described. Large pieces with controlled oriented microstructure have been fabricated and shaped into cylinders, bars, and plates. Current densities up to 10_5 A/cm_3 at 77 K have been obtained magnetically and by direct current measurement. The high current density and critical field make these materials attractive for use in areas such as motors and generators, superconducting magnetic storage for power handling, and passive and active levitation bearings for space applications.

Large Gap Magnetic Suspension System Ground-Based Experiment

Nelson Groom, Aerospace Technologist; Navigation, Guidance, and Control Systems; Langley Research Center

The Large Gap Magnetic Suspension System (LGMSS) is a ground-based experiment which will be used to investigate the critical technology issues associated with magnetic suspension, accurate suspended element control, and accurate position sensing at large gaps. This technology will be applicable to future efforts ranging from magnetic suspension of wind tunnel models to advanced spacecraft experiment isolation and pointing systems. Mr. Groom will describe the system and present an analytical model.

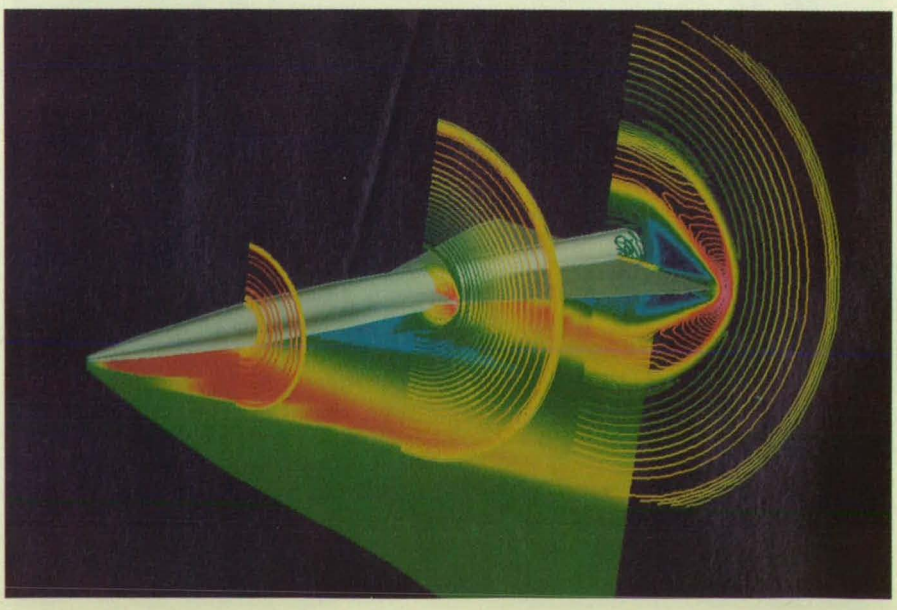
Plenary Session II

2:30 p.m. - 5:30 p.m.

Tapping Into NASA's Technology Storehouse

NASA technology transfer experts will outline the various ways in which conference participants can access NASA's technology and benefit from the agency's scientific and engineering expertise. Attendees will learn:

- how to get NASA's help in solving technical problems;
- how to obtain NASA patents and licenses;
- how to acquire NASA-developed software;
- how to participate in joint NASA-industry applications engineering projects in which existing aerospace technology is reengineered to meet non-aerospace needs;
- how to apply for Small Business Innovative Research (SBIR) awards;
- how to enter into joint research and development projects with NASA.



See cutting-edge applications of computer technology.

WHO SHOULD ATTEND TECHNOLOGY 2000

If you are a research director, project leader, design engineer, scientist, technology transfer agent, or small business owner/president, you cannot afford to miss TECHNOLOGY 2000. Top technology managers and researchers have already registered from the aerospace, electronics, computer, industrial equipment, defense, communications, biomedical, materials, power, transportation, and chemical industries. Reserve your place today!

Show Hours

Symposia are scheduled for the 8:30 to 11:00 a.m. and 2:30 to 5:30 p.m. time slots on both Tuesday and Wednesday, November 27 and 28.
Exhibits will be open from 11:00 a.m. to 5:00 p.m. both days.

The Location

All sessions will be held at the Washington Hilton Hotel and Towers, 1919 Connecticut Ave., NW, Washington, DC 20036. A final program will be distributed at registration indicating session room assignments and location. Registrants may then choose which sessions they wish to attend.

Registration Fees

Preregistration: Full registration fee is $150 and includes technical sessions and exhibits for both days. One-day registration is $100. Preregistrants may visit the exhibit hall only at a cost of $20/day. Your badge will be waiting for you in the registration area at the show; a registration confirmation form will be sent to you via mail.
On-site Registration: Full registration will be $200; one-day registration will be $125; exhibit hall only will be $25/day. Registration will be open from 7:30 a.m. to 3:00 p.m. both days.
Save time and money: Preregister using the convenient form below. Clip and mail with your payment to: Technology Utilization Foundation, 41 East 42nd St., Suite 921, New York, NY 10017.

Hotel Accommodations

The following special rates have been negotiated with the Washington Hilton Hotel for **TECHNOLOGY 2000** attendees: single room - $125; double room - $145. Reservations will be accepted on a first-come, first-served basis and must be made directly with the Washington Hilton Reservations Dept., (202) 483-3000.

Transportation

Ground: The Washington Hilton Hotel is conveniently located near the DuPont Circle stop on the Metro Red Line, and offers plenty of indoor parking.
Air: Special arrangements have been made with United Airlines through Travel Services Group for discounted air fares to attend **TECHNOLOGY 2000**. You can save up to 40% on coach fares or receive an additional 5% off already discounted fares (with restrictions). Make your reservations as soon as possible to assure the flight schedule of your choice. Call 1-(800)-336-0227 between 9:00 a.m. and 5:30 p.m. Eastern time, Monday through Friday.

The Sponsors

TECHNOLOGY 2000 is sponsored by NASA, *NASA Tech Briefs* magazine, and the Technology Utilization Foundation, a not-for-profit organization dedicated to technology transfer. For further information contact Joseph Pramberger, show manager, at (212) 490-3999.

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DEADLINE FOR RECEIPT: NOVEMBER 9, 1990
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K ___ Consultant
T ___ Transportation
S ___ Computers
Q ___ Industrial Eqpt.
C ___ Chemicals
U ___ Education
B ___ Bio-Medical
Z ___ Other _____

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2 ___ Engineering management
3 ___ Engineering
4 ___ Research
5 ___ Other (specify) _____

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4 ___ Basic Research
5 ___ Manufacturing & Production
6 ___ Purchasing & Procurement
8 ___ Other (specify) _____

Your engineering responsibility is:
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B ___ Manage a Project Team
C ___ Manage a Project
D ___ Member of Project Team
E ___ Other (specify) _____

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Full registration $150	$_____
One day $100/day (Circle day: Tues. Wed.)	$_____
Exhibits only $20/day (Circle day: Tues. Wed.)	$_____
Total amount due:	$_____

Full and one-day registrations are transferable, and may be cancelled until Nov. 8 subject to a $50 cancellation charge. After that date, no cancellations will be accepted and no money will be refunded.

Return with your payment to: Technology Utilization Foundation, 41 East 42nd St., Suite 921, New York, NY 10017

TECHNOLOGY 2000 EXHIBITS:
A SHOWCASE OF CUTTING-EDGE TECHNOLOGY

The following companies and research institutions will be among the more than 150 exhibitors displaying new products and technologies at **TECHNOLOGY 2000**. Exhibit hours are 11:00 a.m. to 5:00 p.m. on both Tuesday and Wednesday, November 27 and 28.

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AMP Inc.
Arthur D. Little
Astro-Med
Carnegie Mellon Robotics Institute
Computer Software Management and Information Center (COSMIC)
Corning Inc.
County of Loudoun, Virginia
Cybernet Systems
Datatape Inc.
Deltek Systems
Design And Evaluation
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Dolphin Scientific
Eastman Kodak Company
EG&G Idaho
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Goddard Space Flight Center
GRAFkit
Grumman Space Systems
Hewlett Packard Co.
High Tech Services
Hitachi Chemical Electro-Products
Hi Techniques
Hughes Aircraft
Hyperception
Ideas Inc.
Inductron Corp.
Information Development Inc.
Information Handling Services
Instrument Technology Inc.
Jet Propulsion Laboratory
Johnson Space Center
JP Technologies
JR 3 Inc.
Kennedy Space Center
Langley Research Center
Lewis Research Center
Lockheed Missiles & Space Co.
Lucas Datalab
Marshall Space Flight Center
Martin Marietta Astronautics Group
Martin Marietta Manned Space Systems
Mechanical Technology Inc.
MGA Inc.
Micro Industries Corp.
Micro Surface Corp.
Mikron Instrument Co.
Motorola Inc.
NASA Industrial Applications Center (NIAC)/Applied Research
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Ramtek Corp.
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Ribbon Technology Corp.
Rocketdyne
Rockwell International
Rotating Memory Services
Satellite Data Systems
Scientific and Technical Information Facility (STIF)
Sensor Developments Inc.
Silicon Graphics
Southern Technology Applications Center (STAC)
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Vetronix Research Corp.
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VI Corp.
Water Filter Company of America
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These high-tech leaders will be displaying a wide array of inventions and products available for license or sale, including 3D computer monitors, CD-ROM databases, scientific and engineering software, high-performance workstations, real-time video systems, remote sensing equipment, remote vision instruments, dexterous robot controllers, fluid control components, cryogenic systems, high-strength composites, film deposition techniques, high-temperature lubricants, advanced engine concepts, HeNe lasers, optical components, desktop signal processors, digital signal processing software, digital storage oscilloscopes, and much, much more!

NASA exhibits will feature such innovations as high-tech exercise hardware, an ingestible temperature pill, a medical information management system, an electro-expulsive aircraft deicing system, a "smart" hydrogen sensor, an advanced liquid hydrogen transfer pipe, neural network technologies, and a PC-based image display system for scientific applications.

For information on having your company exhibit at **TECHNOLOGY 2000**, contact Joseph Pramberger or Evelyn Mars at (212) 490-3999.

Electronic Systems

Hardware, Techniques, and Processes

Books and Reports

Data-Acquisition Board for IBM PS/2 Computer

A plug-in unit reads in as many as 48 signals.

Lyndon B. Johnson Space Center, Houston, Texas

A circuit board containing microprocessors is designed to control the acquisition of data by an IBM PS/2 computer. The board is to be plugged into one of the 16-bit slots on the mother board of the computer. Its purpose is to read in a number (up to 48) of discrete signals and transfer them to the Micro Channel interface of the computer to be processed. Data can be read in through one, any combination of two, or three 16-bit channels at a rate of ~1 MHz overall or ~0.33 MHz per channel. With later expansion of software, the board will also be able to recognize and filter specified kinds of signal patterns, possibly to detect errors.

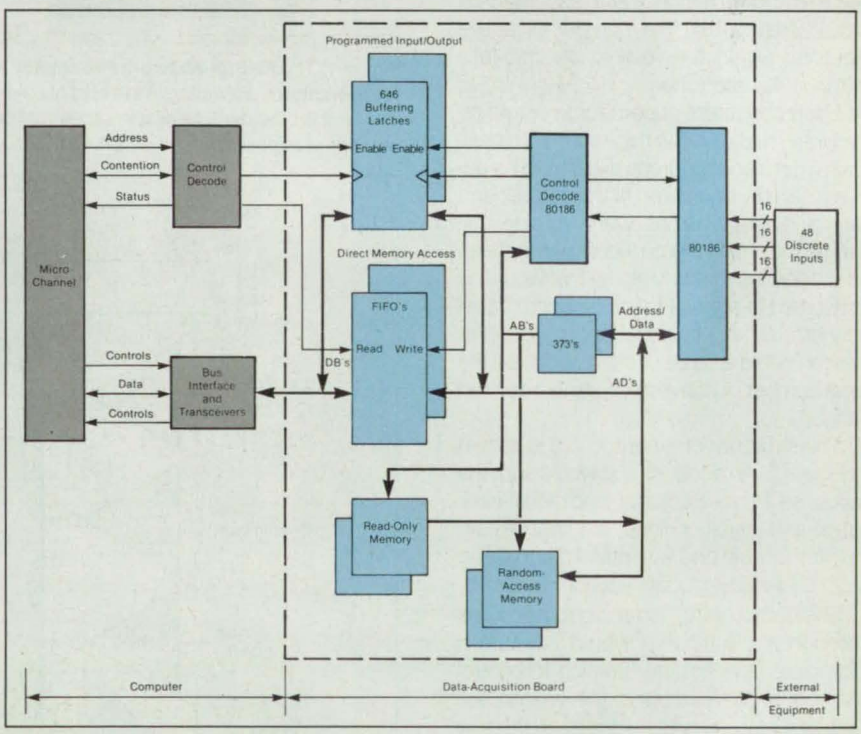
An 80186 microprocessor is used to take in 48 discrete samples via a switching process (see figure). This microprocessor stores the data in a set of first-in/first-out buffers (FIFO's) at a rate as close as possible to 10^5 bytes/second. As new data are written into the FIFO buffer, older data are withdrawn from the FIFO according to the first-in/first-out sequence. Essentially, each "half-full" flag calls for a block direct-memory-access (DMA) transfer of 256 words of data to the PS/2, in burst mode, or for the beginning of a sequence of single transfers. In the latter case, a DMA request is initiated at the beginning of each bus cycle.

After the FIFO's are half full, a sequence of DREQ's (DMA requests) takes place within the board logic, and thus within the interface logic, at the beginning of each bus cycle. This is called the single-transfer DMA Mode. As soon as the DREQ input to the Micro Channel bus interface 82C612 is asserted, the local arbiter of the interface logic places its priority assignment on the arbitration bus. If it has the highest priority among all contestants or if it is the only contestant, it has control of the bus. However, for each transfer, it has to repeat the same routine to compete for the system bus. In case it loses its turn, it has to keep the DREQ line active and thus preempts for another arbitrating cycle, attempting to gain control of the bus.

Once the FIFO's are half full, the "half-full" flag clocks a DMA request for a block of 256 words of data to be read to the Micro Channel DMA controller. Then, the "terminal count" signal from the Micro Channel bus clears this request.

In addition to the DMA data-transfer scheme, the board also supports a program-control implementation of input and output transfers (PI/O) between the 80186 microprocessor and the Micro Channel. For this purpose, there are two control registers, designated "BASE + 00h" and "BASE + 01h." In addition, there are six 646 buffering latches (designated "BASE + 02h" through "BASE + 07h") designed to communicate between the Micro Channel and 80186 data buses. To gain access to the PI/O mode, one simply sets the PIO/DMA bit (bit 1) of control register BASE + 00h to 1.

There are two types of PI/O transfer. In the first type, known as word transfer, each WRITE to input/output registers BASE + 02h (low byte) and BASE + 03h (high byte) from the PS/2 latches the designated data onto the buffer. Through interrupt handshaking (80186 INT0 or INT1), the 80186 reads data from the buffer and processes them (if suitable firmware is implemented). PI/O WRITE from the 80186 also causes the PS/2 to read from the registers BASE + 04h (low byte) and BASE + 05h (high byte) through Micro Channel interrupt requests, which are to be selected within the programmable-option-select registers.



The **Data-Acquisition Board** controls the transfer of data from as many as 48 discrete channels to the Micro Channel interface.

The second type of PI/O transfer is known as byte transfer and is similar to word transfer. However, only the low byte latch is used. Data written to the high byte should all be zeros.

This work was done by Phuong-Dung T. "June" Hoang of **Johnson Space Center**. *For further information, Circle 139 on the TSP Request Card.*
MSC-21590

Neural-Network Processor Would Allocate Resources

Global optimization problems could be solved quickly.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed artificial neural network would perform a globally optimal allocation of *M* resources among *N* expenditures according to a prescribed set of rules. The concept of the network has evolved during the continuing effort to understand biological neural networks and to develop electronic networks that imitate some of their functions. Potential applications of the proposed resource-allocating processor include the assignment of jobs, scheduling, dispatching, and planning of military maneuvers.

The processor would include a matrix of $M \times N$ cells, each of which would represent the pairing of one of the resources with one of the expenditures (see Figure 1). The cost of the pairing would be stored in analog form in each cell. For each row and each column, a constraint superneuron would ensure that the number of active neurons within the row or column falls within a desired range.

Each constraint superneuron would be programmed with the minimum and maximum number of neurons allowed to be active in its row or column. If the actual number of active neurons were outside this range, the superneuron would generate an inhibitory or excitatory signal that would be presented in parallel to the neurons of that row or column. A global constraint superneuron could also be used to constrain the total number of active neurons to a desired range.

The structure of a neuron cell is shown in Figure 2. An adder circuit would sum the inputs on the row, column, and global-excitation and inhibition lines; the cost of pairing in this cell; and a simulated-annealing term for avoiding local minimum solutions.

The output of the adder would be routed through a circuit that would execute a sigmoidal thresholding function to control the gain and dynamics of the system; the resulting value would be added to the row and column summation lines. A global summation line could be derived by adding across all row or column summation lines. Simulated annealing would be performed with the help of an analog noise generator scaled by a multiplier or, alternatively, by varying the slope of the threshold function. The system would settle into a stable state consistent with the given set of constraints with a convergence time dictated by the neuron response time and the annealing state. The state of each neuron could be read by using a multiplexer to poll each cell or each row.

This work was done by Silvio P. Eberhardt and Alexander W. Moopenn of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 122 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL *[see page 18].* *Refer to NPO-17781*

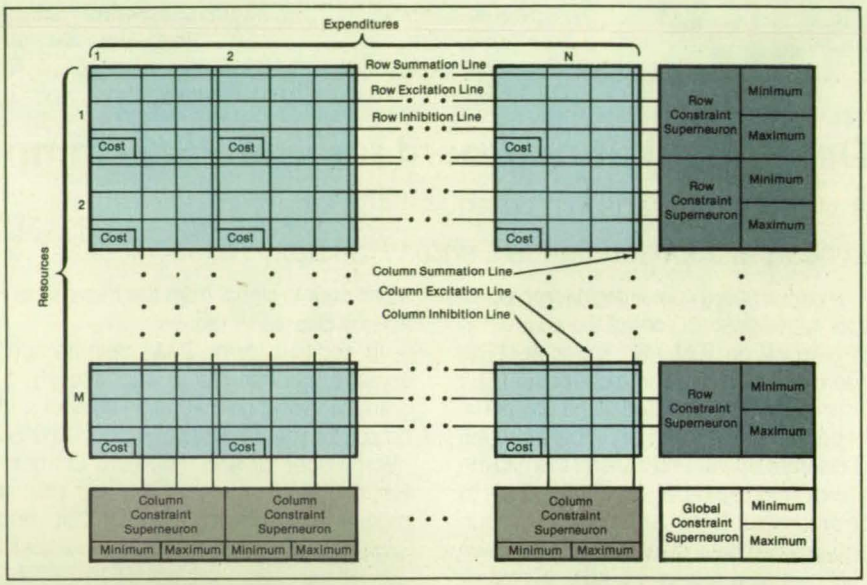


Figure 1. The **Neural-Network Processor** would optimize the allocation of M resources among N expenditures according to the cost of pairing each resource with each expenditure and subject to a limit on the number of resources that can feed into each expenditure and/or a limit on the number of expenditures to which each resource can be allocated.

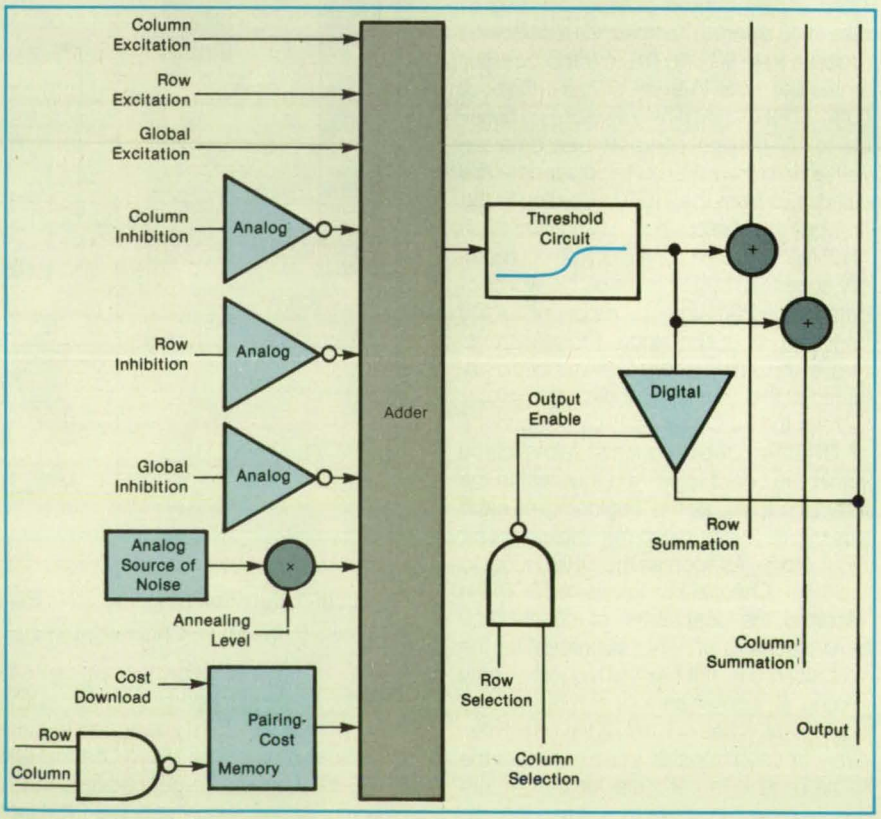


Figure 2. **One Cell** of the neural-network processor would perform several analog and digital functions.

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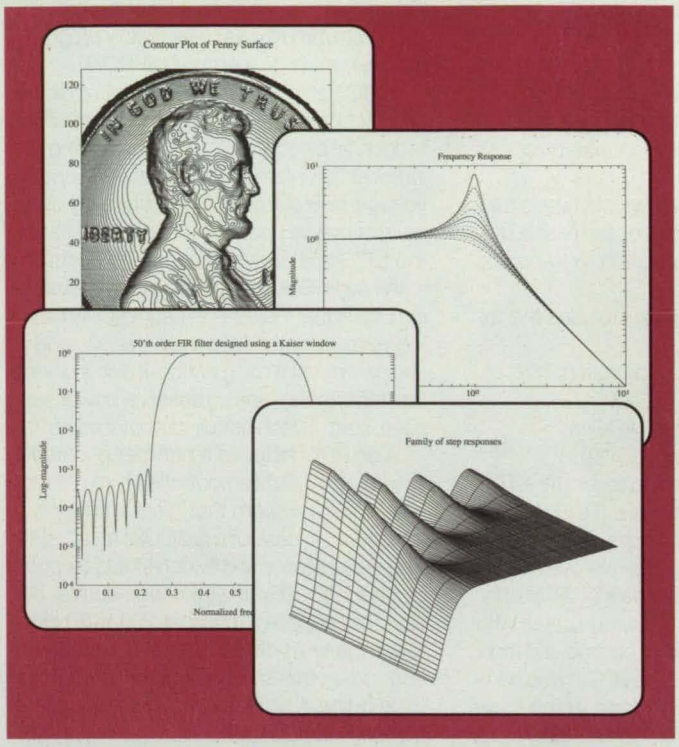

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NASA 10/90

Circle Reader Action No. 503

Automated Power-Distribution System

The system monitors and controls ac and dc electrical power to modular loads.

Marshall Space Flight Center, Alabama

An automated power-distribution system monitors and controls electrical power to modules in a network. The system handles both 208-V, 20-kHz single-phase alternating current and 120- to 150-V direct current. Potential applications include autonomous land vehicles and automated industrial process systems.

The power-distribution system needs minimal attention. It can detect faults and protect against them, in addition to switching and monitoring loads.

The system (see figure) includes the following:

- Switchgear interface controllers (SIC's),
- Generic controllers (GC's),
- Analog-to-digital cards (ADC's),
- Remote bus isolators (RBI's),
- Remote-controlled circuit breakers (RCCB's),
- Remote power controllers (RPC's), and
- Various monitoring circuits.

An SIC processes 19 different commands from a lowest level processor (LLP) and returns response data. It communicates with 14 GC cards, each of which controls and monitors an RBI, an RCCB, or an RPC. It also communicates with an ADC, from which it receives 16 voltage, current, and temperature signals from sensors. The SIC processes all this information in an 8-bit microprocessor programmed via an electrically programmable read-only memory (EPROM).

A GC card decides, on the basis of the information it receives from its SIC, whether to turn a switch on or off, depending on whether the information indicates an undervoltage, overcurrent, surge current, ground fault, or overtemperature condition. It sends the SIC serial data indicating its decision.

An ac RPC is an alternating-current-switching circuit that includes a magnetically latching relay, a main solid-state switch, and a parallel current-limiting switch. It also includes fast-trip circuitry, analog sensors, power supplies, and switch-status output circuitry.

A dc RPC includes a number of parallel solid-state switches controlled by a closed-loop control system that limits current automatically in case of a fault. Like an ac RPC, it provides sensor and switch-status outputs.

An ac RCCB is an alternating-current device that supplies 10 kW at 208 V, 20 kHz, to as many as three RPC's. It includes a large relay that switches both sides of the 20-kHz line. A dc RCCB includes solid-state switches in parallel, sensor and switch-status outputs, and both overcurrent- and undervoltage-shutoff circuitry.

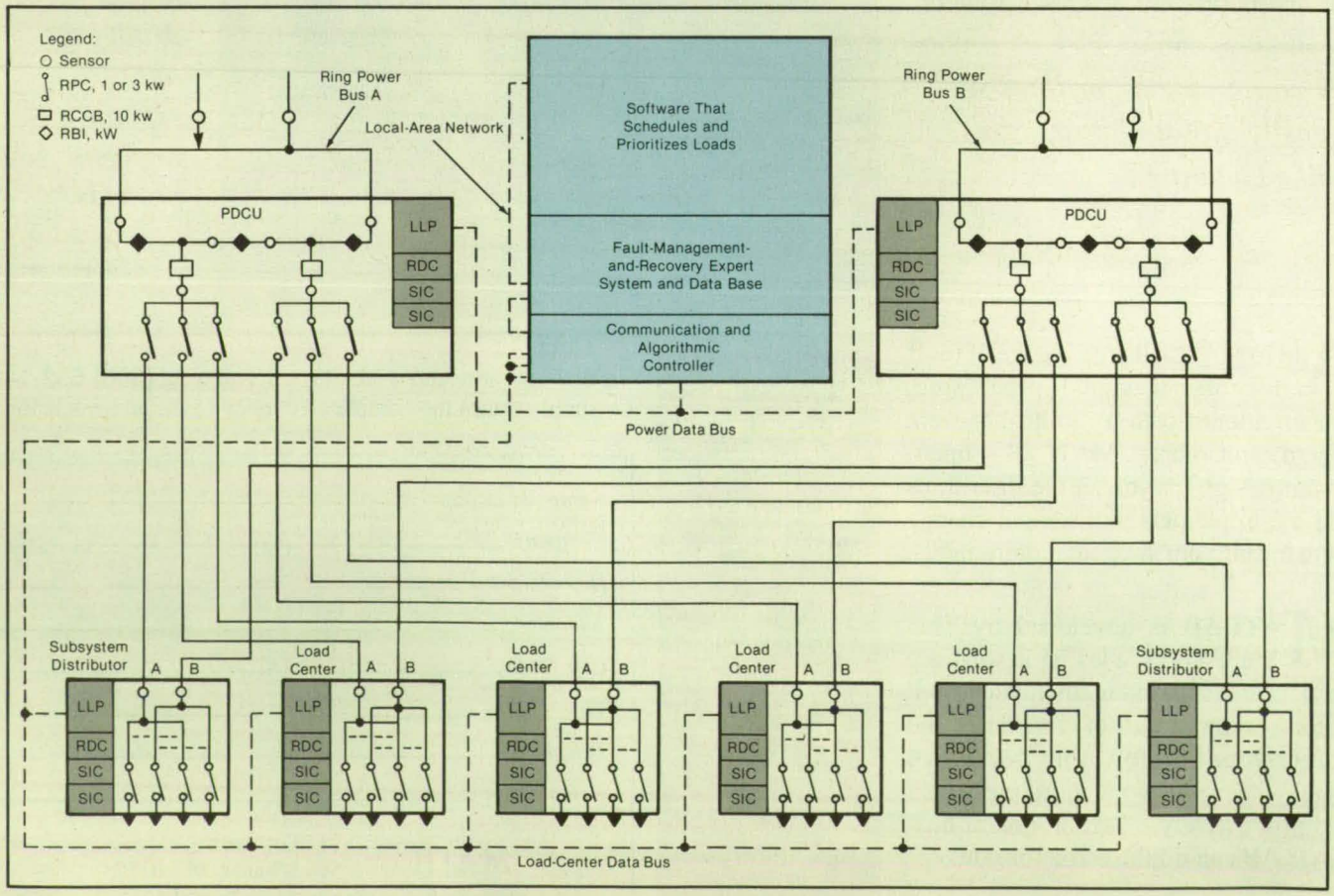
RBI's carry power to the RCCB switches. An RBI includes a large relay that switches both the positive and return sides of the powerline. It provides the GC card with relay-status information only, and can be switched only when the input power is off.

ADC's convert analog signals from sensors into 8-bit digital signals. They transmit, to the SIC's, digitized data on voltages, currents, powers, power factors, and temperatures.

The system responds quickly to faults. For example, it responds to a 175-percent overcurrent with a 1-μs initial reaction and a 15- to 50-ms settling time, or to a 125°C over temperature in 50 ms.

This work was done by Cindy Thomason of **Marshall Space Flight Center** *and Paul M. Anderson and James A. Martin of Martin Marietta Corp. For further information, Circle 72 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page ***18****]. Refer to MFS-28440.*



Power Is Distributed to Load Modules from power-distribution control units (PDCU's) via subsystem distributors. Ring busses carry power to the PDCU's from the power source.

PEP Card News 1990

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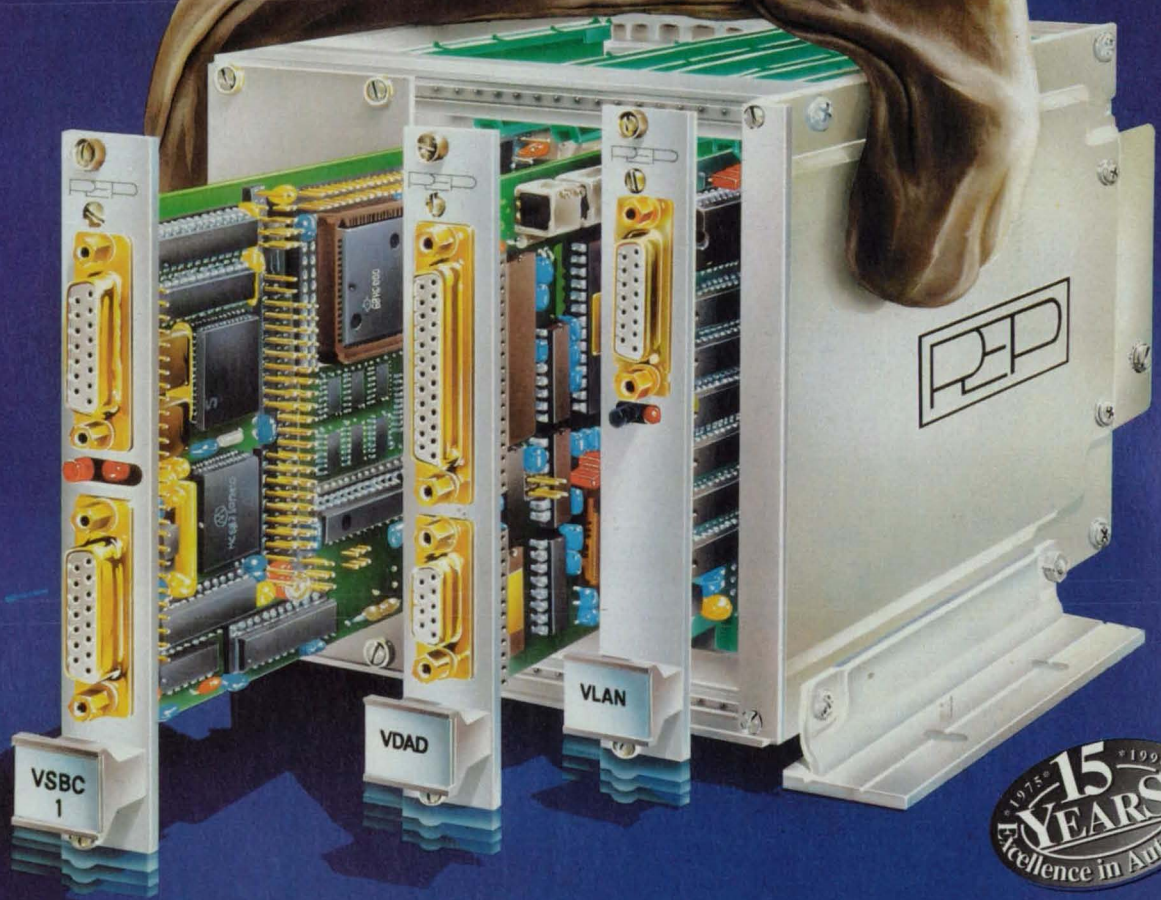

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Proximity Sensors Make Robot Dexterous

Reflected beams measure distances and orientations of objects for grasping.

Lyndon B. Johnson Space Center, Houston, Texas

A control system enables a robot hand to grasp objects of varied shapes. Key features of the system are (a) reflective proximity sensors that furnish data on the position, orientation, and distance of the object and (b) a software protocol that controls the sequence of operations in approaching and grasping the object.

As the hand approaches an object, the outermost proximity sensors (those near the tips of the fingers) detect the object. If any of the outer sensors do not detect the object, the system reorients the hand until they do. This arrangement makes the axis of approach of the hand perpendicular to the principal axis of the object — the best orientation for reliable grasping (see Figure 1).

Each sensor sends a beam of light to the target and detects the reflected beam to measure the distance from the sensor to a point on the object. A gain-adjusting circuit compensates for the variation in the strength of the reflected signal with distance. This scheme enables the sensors to work at distances of 0 to 4 in. (10 cm).

From the measurements, the system directs the fingers to arrange themselves along the contour of the object, wrapping around the object without touching it. The system thus forms a trap around the object and minimizes the probability that the object will escape. Even if the object is too large for the hand to encircle it fully, such contour following provides the largest possible grasping surface.

The system then directs the fingers to close in on the object and secure it by applying force. If the object becomes slightly misaligned during the closing operation, the system reorients the hand or fingers to maintain the best spatial relationship (Figure 2). The reflected-beam sensing concept can be applied to simple opposed-jaw industrial grippers as well as to dexterous robot hands. In gripper applications, it will enable reorientation of grippers to align them with the objects to be grasped, followed by controlled trapping of the objects.

This work was done by Cliff Hess and Larry C. H. Li of **Johnson Space Center**. *For further information, Circle 144 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 18]. Refer to MSC-21476.

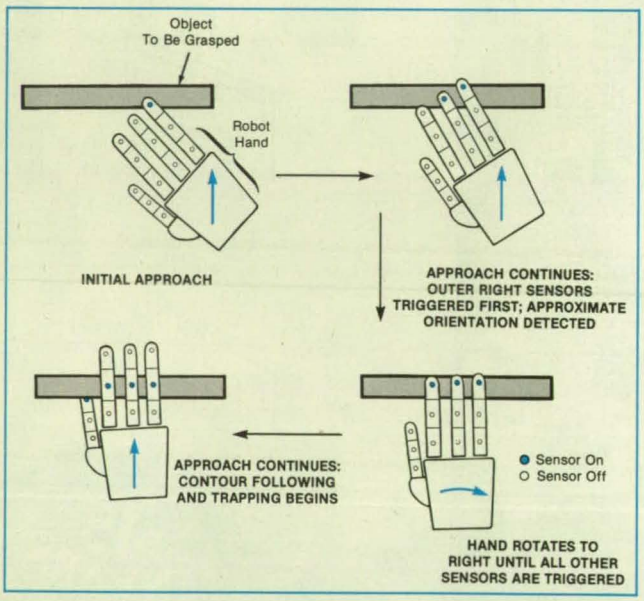

Figure 1. On **Initial Approach**, a hand rotates clockwise until all sensors on the fingertips are triggered. When the hand is aligned perpendicular to the axis of the object, it continues its approach and starts to follow the contour of the object.

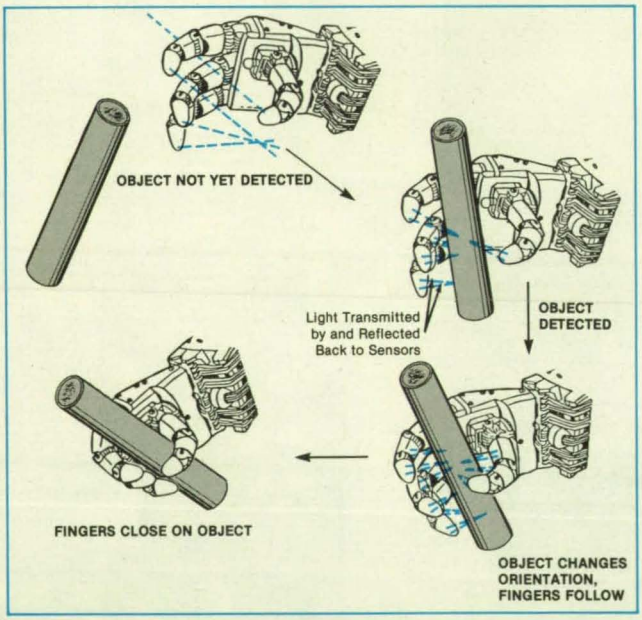

Figure 2. As **Fingers Close on the Object**, the hand continues to reorient itself as necessary. After trapping the object, the fingers finally touch it and hold it.

Master/Programmable-Slave Computer

Features include versatility, low power, and large memory.

Lyndon B. Johnson Space Center, Houston, Texas

A unique modular computer features compactness, low power, mass storage of data, multiprocessing, and the choice of various input/output modes. Although the computer is designed for use in the control of a complicated bioreactor and associated experiments, its modular, versatile nature makes the general design concept adaptable to industrial process control with selectable degrees of automatic control, automatic and/or manual monitoring, and manual intervention.

The computer includes a master processor and 24 slave processors. Each processor is mounted on a circuit card in a 25-slot card cage (see Figure 1). The primary functions of the master processor are to program the slave processors for operations based on random-access memory, to regulate and provide communications between slave processors, to transfer data to and from a mass storage device, and to act, when so required, as an interface between the computer and a human operator. The master processor monitors the slave processors for proper operation and is equipped to reset a slave processor that is not functioning properly. In addition, the master can reset or reprogram any slave at will. When power is first

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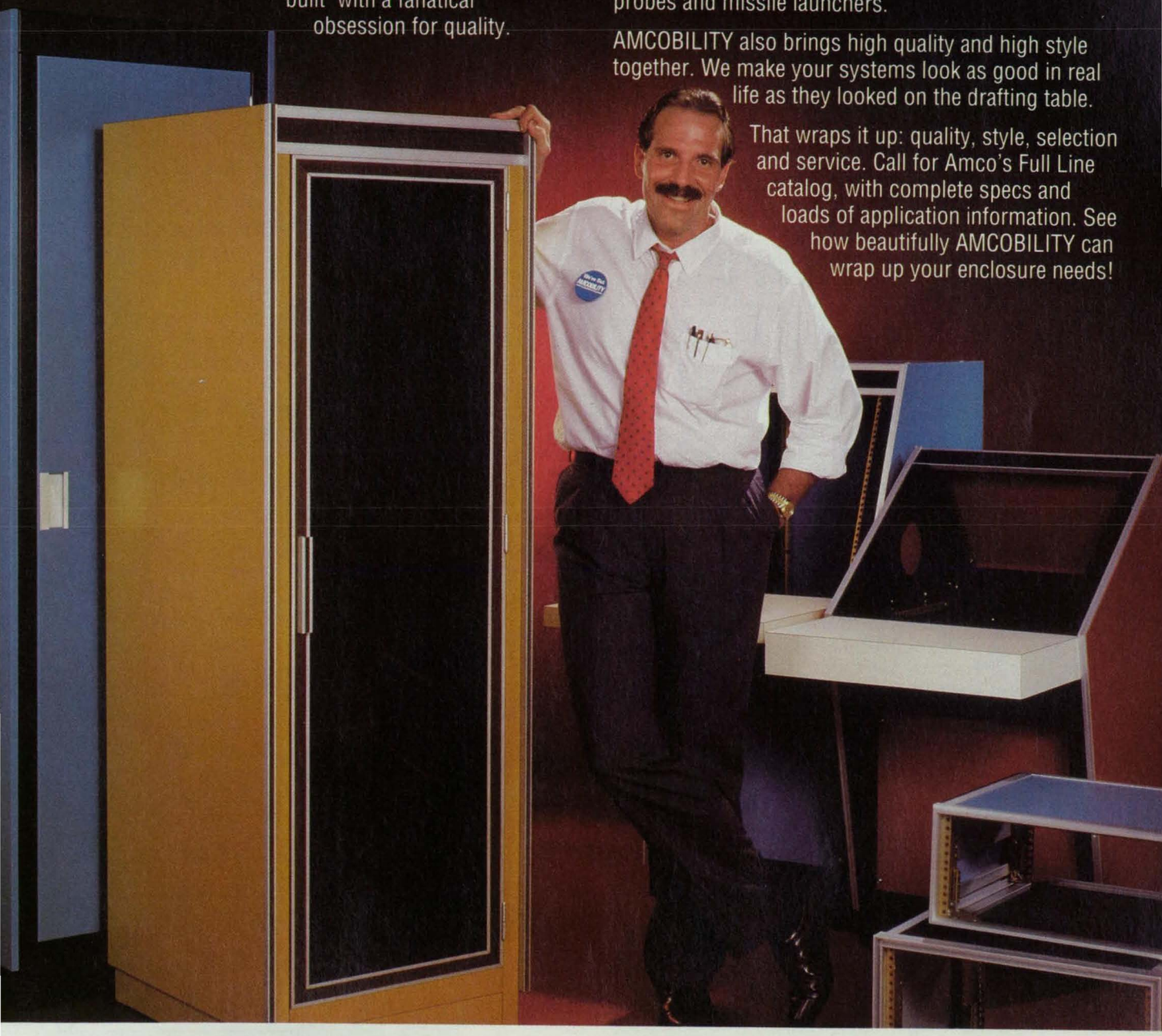

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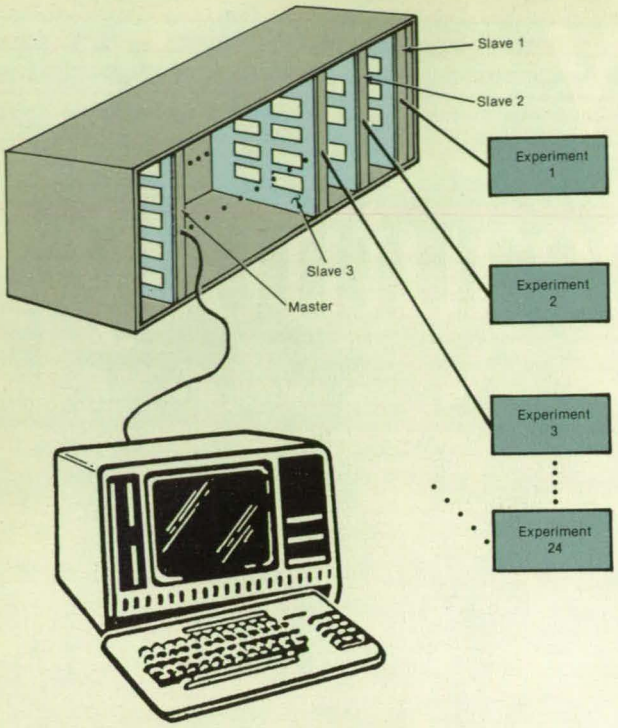

Figure 1. The **Master Processor Communicates With the User** via the usual keyboard and video display terminal. The master processor coordinates the operations of as many as 24 slave processors, each dedicated to a different experiment.

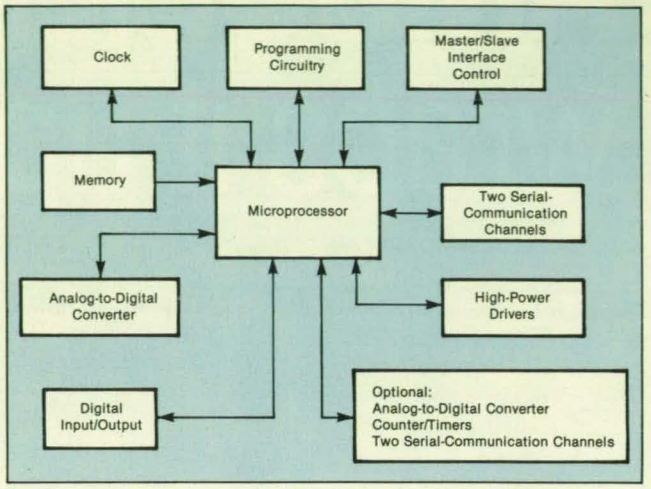

Figure 2. Each **Slave Circuit Card** includes the slave microprocessor and an assortment of input/output circuits for communication with external equipment, with the master processor, and with other slave processors.

turned on or when the master commands a reset, all the slaves wait for permission from the master to run their application programs.

The slave cards do not perform any managerial functions and are dedicated to process-control functions. Each slave card — a computer in itself — is equipped with a number of different input/output capabilities so that it can communicate with the process or equipment that it controls, with the master processor, and with the other slave processors (see Figure 2). A slave processor sends information to another slave processor by "flagging down" the master processor and sending the information to the master processor along with instructions as to where the information is to go. Each slave card can, when necessary, operate independently of the master and the other slaves, processing input/output data by use of its own control program. Each slave card is specialized for its assigned process or external equipment by the inclusion of such input/output devices as analog-to-digital converters, memories, and driving amplifiers for dc motors, stepping motors, and relays.

This work was done by David Smaistrla and William A. Hall of KRUG International for **Johnson Space Center**. *For further information, Circle 35 on the TSP Request Card. MSC-21550*

Microprocessor Control for Liquid-Cooled Garment

Uncomfortable overshoots and undershoots of temperature are eliminated.

Lyndon B. Johnson Space Center, Houston, Texas

An automatic control system maintains the temperature of a water-cooled garment within the comfort zone while the wearer's level of physical activity varies. Although designed for use in a space suit, the control system is clearly adaptable to other protective garments and to enclosed environments that operate according to similar principles.

Previously, the wearer controlled the temperature through manual adjustments of a valve that controlled the portion of the flow of water shunted around a heat exchanger. Because of variability in the workload and unpredictability of the thermal response of the wearer's body, the wearer had to hunt repeatedly for a comfortable setting, and the temperature frequently overshot and undershot the comfort zone.

The control system relies on the empirical finding that the wearer is most comfortable over a wide range of metabolic rates when the temperature T_i of the liquid at the inlet of the garment lies along a nearly straight line on a plot of T_i versus $\Delta T = T_o - T_i$, where T_o = the temperature of the liquid at the outlet of the garment (see Figure 1). The system (see Figure 2) repeatedly samples T_i, T_o, and the temperature T_h at the output of the heat exchanger and feeds these signals as inputs to a microprocessor that generates valve-command signals according to a model-reference control concept.

The microprocessor executes an algorithm that seeks to make the samples of ΔT converge toward theoretical sample values ΔT^* computed according to the model to keep the temperatures near the line of greatest comfort. When the temperatures lie outside the comfort zone, the model accelerates to much faster than the actual operating rate in the search for a candidate inlet temperature, T_c. Initially, the search is conducted by an iterative method; if that fails after a specified number of iterations, a noniterative method is used. When the system finds a T_c that yields ΔT^* in the comfort zone, it adjusts the actual T_i to this value of T_c.

In the model resident in the algorithm, the slowly varying component of T_i is ob-

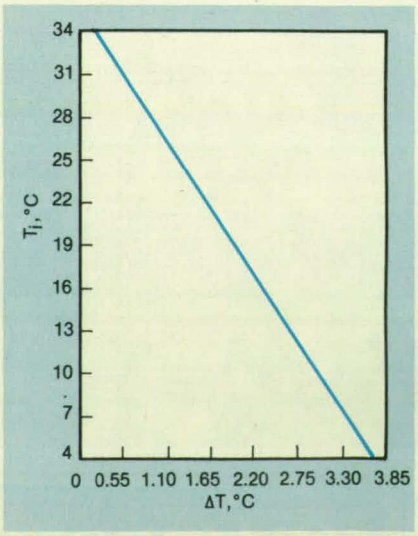

Figure 1. The **Comfort Zone** is a band of temperatures extending about 1 °C above and below this plot.

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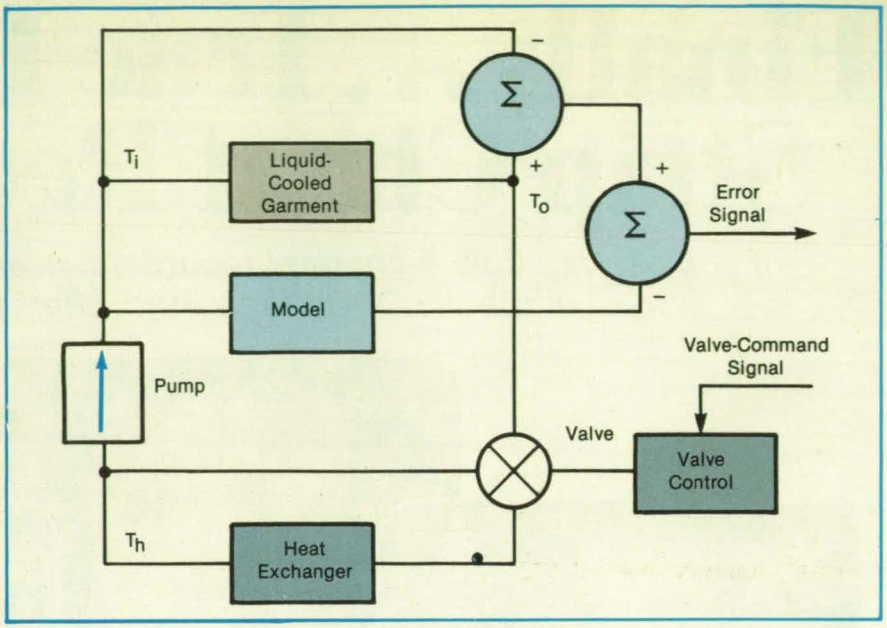
Figure 2. The **Model-Reference Automatic Control System** adjusts T_i to keep T_i and $T_i - T_o$ within the comfort zone as the heat load varies.



tained by low-pass filtering and multiplied by a suitable gain to obtain a slowly varying component of ΔT^* along the comfort line. The high-frequency component of T_i is fed to an adaptive filter, which imitates a tapped delay line. The weights of the taps are adjusted according to a subalgorithm to obtain a rapidly varying component of ΔT^* that minimizes the mean-square difference between ΔT^* and ΔT in a sequence of samples.

This work was done by Charles S. Weaver of SRI International for **Johnson Space Center**. *For further information, Circle 105 on the TSP Request Card.*
MSC-21359

Ultrasonic Imaging of Deep Arteries

Swept-frequency sound replaces pulsed sound.

NASA's Jet Propulsion Laboratory, Pasadena, California

An ultrasonic medical instrument produces images of peripheral and coronary arteries with resolutions higher and at depths greater than those attainable by previous ultrasonic systems. The instrument is intended for use in the noninvasive detection and measurement of atherosclerotic lesions.

Conventional pulse-echo ultrasound imagers are now approaching the limits of their resolution for deep-lying arteries. Pulses are severely attenuated at high frequencies as they penetrate deeply into tissue, and their echoes therefore have poor signal-to-noise ratios. The farther the pulses penetrate, the less the image information that can be extracted from them.

The new instrument uses time-delay spectrometry; it transmits sound continuously as its frequency is swept, detects the reflected sound by heterodyning, and analyzes the spectrum of the reflected sound. Echoes arrive at the receiver with a delay that depends on the length of the transmission path and the speed of propagation. Because the transmitted frequency is swept, the delay corresponds to a frequency offset. Thus, by selecting an appropriate offset frequency and bandwidth, an equivalent interval of time or distance into the tissue can be selected.

A major benefit of the time-delay spectrometry system is that it transmits over a wide, controlled range of frequencies while using a matched filter in the receiver. The matched filter yields the best possible signal-to-noise ratio in the white-gaussian-noise environment typical of tissue measurements. It has been calculated that a version in which the frequency is swept from 0 to 10 MHz in 20 ms yields a 53-dB improvement in processing gain over that of a pulse-echo system that uses the same peak transmitted power.

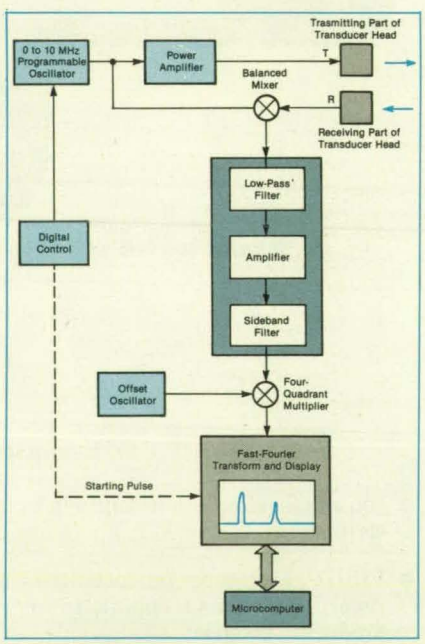
The instrument is illustrated schematically in the figure. An ultrasonic signal at a linearly swept frequency is transmitted into the tissue. The received signal is coherently mixed with the input signal and low-pass filtered to remove unwanted high-frequency components. A fast Fourier transform converts the remaining frequency components into a display in which the horizontal axis represents time (or, equivalently, range or depth) and the vertical axis represents intensity of the return signal. An image of the tissue can be generated by scanning the ultrasonic transducer across the surface of the tissue. Images are relatively free of the clutter and speckle that plague most ultrasound images.

Most of the spectral information is collapsed to form an image. The information remains in the instrument, however, and can readily be obtained when needed.

The new instrument does not yet operate in real time. Images must be averaged over several cardiac cycles, with some loss of resolution because of the movement of tissue. However, with faster digital electronics and improved ultrasonic transducers, the instrument will be able to produce images in real time, and the resolutions of images will be even better.

This work was done by James A. Rooney, Richard C. Heyser, and Dennis H. LeCroissette of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 58 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17439.



The **Time-Delay-Spectrometry Imager** includes scanning, image-processing, and displaying equipment. It sweeps in frequency from 0 to 10 MHz in 20 ms, pauses for 5 ms, and repeats the sweep.

Time-Resolved Measurements of Laser Far-Field Patterns

Far-field patterns are sampled at discrete times during pulses.

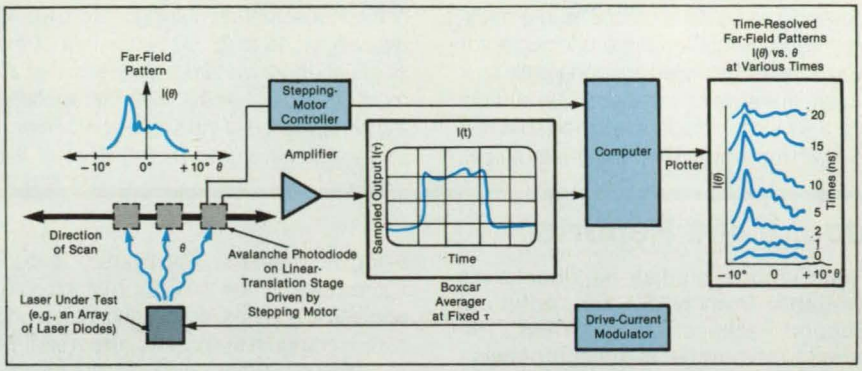
Goddard Space Flight Center, Greenbelt, Maryland

A computer-controlled scanning photometric instrumentation system measures the intensity pattern in the far field of a pulsed laser as a function of time during each pulse (provided that a pulse is at least 1 ns long). Time-resolved measurements of the far-field radiation pattern are important in assessing the utility of a laser for laser communication, optical recording, remote sensing, or pumping another, solid-state laser. Such measurements are also important in studying the dynamics of laser operation: they can reveal such previously unobservable phenomena as oscillations of undesired spatial modes of the radiation pattern during the pulse, steering of the beam during the pulse, and instability in the intensity of the laser beam.

The principal advantages of the system are its relatively low cost — about $30,000 (1990 prices) — and its ability to function under normal lighting conditions without incurring damage. A streak-camera system can make time-resolved measurements of far fields but typically costs more than $150,000 and must be used in complete darkness (except for the light being measured) to prevent damage by stray light.

The laser under test is placed in a test fixture and pulsed repeatedly by modulating its drive current. A silicon avalanche photodiode that has a frequency response of 3 GHz and a 100-μm collecting aperture is placed 57 mm away from the laser on a translation stage driven by a stepping motor. The computer that controls the system causes the stepping motor to translate the stage and photodiode 20 mm across the laser beam in steps of 100 μm; this corresponds to an approximate angular scan across the far field of –10° to +10°, with angular resolution of 0.10°. The output of the photodiode at each angular step is digitized by a boxcar averager capable of sampling time-varying phenomena with a resolution of 12 ps. The output of the boxcar averager is stored by the computer in a specific "angular point" file.

The result of the scan is a set of files of data on intensity versus time for each angular scan point in the far field. The far-field pattern of the test laser for a particular time in the pulse can then be plotted by extracting the intensity value for that time from each angular-point file. The computer then plots the entire far field for the specific time in the pulse. As many as 20 far-field patterns can then be stack-plotted to reveal the evolution of the far-field pattern during the pulse. The temporal resolution of the overall system is 330 ps.



This **Instrumentation System** makes time-resolved measurements of the far-field radiation pattern of a pulsed laser. One of the principal advantages of this system is that it costs much less than does a streak-camera system designed for the same purpose.

This work was done by Kathrine Forrest and Donald Cornwell of **Goddard Space Flight Center.** *No further documentation is available.*

GSC-13338

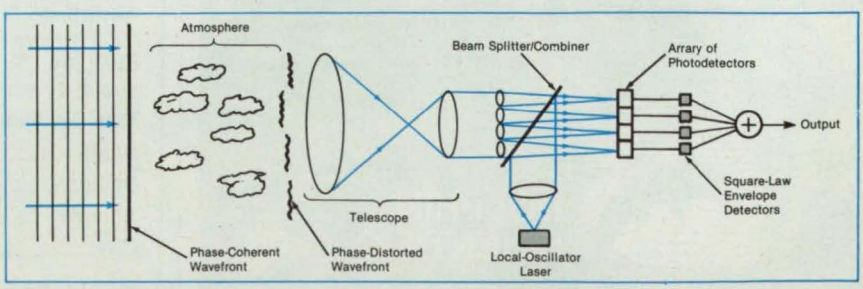
Noncoherent Combination of Optical-Heterodyne Outputs

Performance in the presence of atmospheric turbulence would be improved.

NASA's Jet Propulsion Laboratory, Pasadena, California

In a proposed scheme for the reception of amplitude- or frequency-modulated signals transmitted optically through the atmosphere, the main receiver aperture would be divided into subapertures equipped with receivers, and the outputs of the receivers would be combined noncoherently. Although this scheme is not optimal in the ideal case of a planar, coherent incident wavefront and precisely fabricated, diffraction-limited, large-aperture receiver optics, it can offer superior performance in the presence of a distorted wavefront and/or imperfect receiver optics.

In the ideal case, the best performance is obtained when the incident light is collected by a single, large-aperture telescope or other optical system that focuses the light onto a single heterodyne receiver; this depends on accurate matching of the wavefronts of the incoming and local-oscillator signals. However, in the nonideal case, it is difficult to match the wavefronts adequately in a receiver of large aperture, because it is difficult to fabricate a high-quality optical surface of large aperture. Furthermore, the refractive effects of atmospheric turbulence can cause random fluctuations in the phase and amplitude of the signal, resulting in destructive interference between portions of the wavefront that arrive at the receiver



Multiple Subaperture Receivers would be used instead of attempting to focus all the light from a single large aperture onto one receiver. The outputs of the receivers would be combined after demodulation. This system would not perform as well as a fully coherent system would, but could surpass a single-large-aperture system in the presence of atmospheric turbulence.

from different parts of a large aperture. Thus, in the nonideal case, the performance of a receiver does not improve when the aperture is enlarged beyond a size related to the scale of the imperfections.

Each subaperture receiver in the proposed scheme would include combination with a heterodyne local oscillator and the output focused on a photodetector. The intermediate-frequency output of the photodetector would be demodulated noncoherently by a square-law envelope detector. The outputs of the envelope detectors would be summed to obtain the final receiver output (see figure).

Theoretical analyses and Monte Carlo simulations have been performed to quantify the relative advantages and disadvantages of the single, diffraction-limited, large-aperture scheme and the multiple-subaperture, noncoherent-combining scheme. The analyses show that in the absence of atmospheric turbulence, the signal-to-noise ratio of a noncoherent-combining system would typically be 15 to 25 dB below that of the single-aperture system. However, when atmospheric turbulence is taken into account, the performance of the single-aperture system would be limited by the sizes of the phase-coherence cells of the atmosphere. In that case, the noncoherent-combining scheme should be considered. For a given overall collecting-aperture area, the receiver would be optimized by making the diameter of each subaperture equal to the phase-coherence length of the atmosphere.

This work was done by Chien-Chung Chen and James R. Lesh of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 12 on the TSP Request Card.*
NPO-17693

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Tests of a Differential Global Positioning System

Performance of a helicopter-approach navigation system is described.

A paper describes validation tests of a global positioning system (GPS) for low-flying helicopters. The system is configured as a differential GPS, in which components in both the aircraft and the ground station compute the position errors relative to a known location using satellite navigational data. Differential GPS corrections are computed from the differences between computed and measured ranges to four satellites being tracked by the receiver in both the aircraft and ground systems. The tests were conducted to determine whether the equipment and computer programs of the system operated correctly and consistently.

The tests were carried out with a helicopter on the ground next to the ground-based equipment. The range-bias errors identified by the equipment on the ground and the equipment in the aircraft were sufficiently well correlated to justify the conclusion that the components were operating properly and that flight testing could proceed. The average error in static tests was less than 1.7 meters in all three coordinate axes — less than predicted by theory. In dynamic tests where the helicopter performed terminal approach operations, the lateral error was less than 6 meters and the vertical error was less than 8 meters.

The tests showed that range-domain filtering is an effective means of reducing noise in the differential corrections transmitted by the ground station. However, in-

tegrating monitoring features should be built into the ground system to indicate the performance level in real time and to detect substandard operation.

This work was done by F. G. Edwards, and D. M. Hegary of **Ames Research Center** *and R. N. Turner, F. van Graas, and S. Sharma of Ohio University. To obtain a copy of the report, "Validating the Airborne and Ground Based Components of a Differential GPS System," Circle 6 on the TSP Request Card. ARC-12313*

Study of Adaptive-Array Signal Processing

Techniques for the suppression of interference are compared.

A report describes a study of adaptive signal-processing techniques for the suppression of mutual satellite interference in a mobile (on the ground)/satellite communication system. There are two types of mutual satellite interferences. One type occurs when an Earth station receives. It can receive the desired signal from the satellite in the main lobe of its antenna while receiving an interfering signal from another satellite in a side lobe. The other type of interference occurs when an Earth station transmits. The portion of the signal radiated by one of its side lobes can be received by a satellite not intended to receive it and retransmitted by that satellite as an interfering signal along with the signal from another Earth station that it is intended to retransmit.

The study was motivated by the need for an effective low-cost technique that can exploit the geometrical or temporal differences between the desired and interfering signals. Although, in principle, such a technique could be used either at the satellites or at the mobile units on Earth, the emphasis in this study is on the latter.

The report presents analyses and numerical simulations of the performances of two approaches to signal processing for the suppression of interference. One approach, known as "adaptive side lobe canceling," involves the use of a primary antenna and a reference antenna that has a different radiation pattern in a phased array in which the amplitude and phase of the reference radiation beam relative to those of the primary radiation beam are controllable. The direction of an interfering satellite can be estimated during reception and used to place a null in the overall radiation pattern in the direction of the interfering satellite during transmission.

The second approach, called "adaptive temporal processing," is potentially the approach of lowest cost because it operates only on the primary beam. Adaptive time-domain filtering techniques that exploit both amplitude and Doppler-frequency offsets between the desired and interfering signals have been developed. One such technique involves the use of a cross-coupled phase-lock loop, in which one of two phase-lock loops locks onto the desired signal, while the other locks onto the interfering signal. An alternative technique, called the constant-modulus algorithm, senses and removes the incidental amplitude modulation of the received signal by interfering signals.

The basic conclusion that emerges from the study is that, of the approaches considered, adaptive side lobe canceling provides the most effective means for the suppression of mutual satellite interference. Furthermore, by using digital technology and developing custom microcircuits, one can reduce the cost of augmenting the existing mobile/satellite communication system with adaptive interference-suppression capability.

This work was done by Edgar H. Satorius of Caltech and Lloyd Griffiths of USC for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Final Report on Adaptive Array Signal Processing Study," Circle 101 on the TSP Request Card.*
NPO-17492

Physical Sciences

Schlieren System for Flow Studies in Round Glass Pipes

Cylindrical lenses compensate for refraction in the walls.

Langley Research Center, Hampton, Virginia

In a schlieren system for studying the flow of a gas in a transparent pipe of circular cross section, cylindrical lenses placed on opposite sides of the pipe compensate for the refraction caused by the wall of the pipe. In a typical schlieren system, a parallel beam of light produced by a point light source and collimator passes through the test cell. A second collimator operating in reverse then focuses the beam back to a point. A knife edge is placed at that point, so that it grazes the beam, cutting off about half the light. Variations in the flow of gas give rise to gradients in the index of refraction, which deflect the beam slightly as it passes through the test cell. As the beam passes the knife edge, those deflections are translated into variations in intensity. The intensity decreases or increases, depending on whether the deflection of the portion of the beam from a given region in the test is toward or away from the knife edge, respectively.

If the test cell is a circular pipe, the wall of the pipe acts as a slightly diverging lens. Therefore, in this system (see Figure 1), the first cylindrical lens causes the beam of light entering the pipe to converge just enough that the rays of light become parallel again as they reach the interior of the pipe. As the light leaves the interior of the pipe on the opposite side, the wall again introduces a slight divergence, and the second cylindrical lens reconverges the rays to parallelism. Figure 2 shows a schlieren photograph taken with the new system. Such schlieren visualization supplements other flow data like measurements of velocity, pressure, and temperature.

The new system enables direct visualization of such phenomena as laminar or turbulent flow, shock waves, vortexes, and flow separations in systems that have inherently cylindrical geometry; potentially unreliable extrapolations from results in flat-sided test cells are no longer necessary. For example, secondary flows caused by joints and elbows in circular pipes are different from those in rectangular pipes. Also, turbulence can be reduced unrealistically near the corners in rectangular test cells, and transitions between circular and rectangular cross sections can cause flow anomalies.

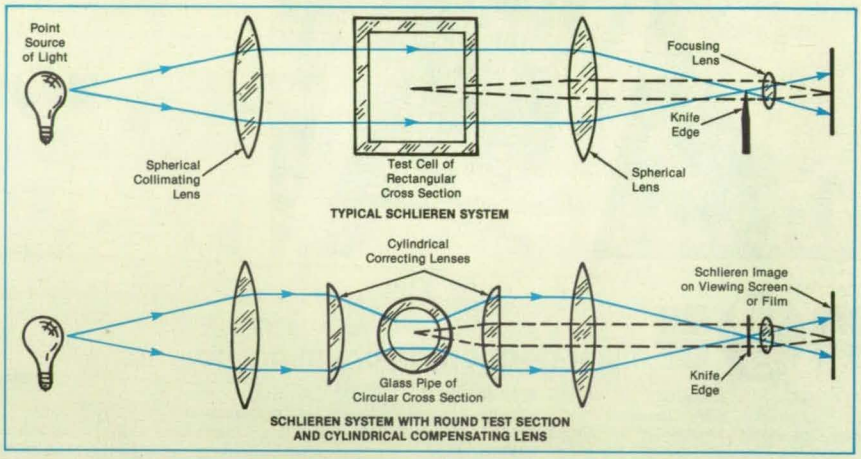


Figure 1. In a **Typical Schlieren System** (above) the test cell has flat sides, which do not focus or defocus the beam of light. The new schlieren system (below) for studying flow in a pipe of circular cross section includes two cylindrical lenses that compensate for the refraction that occurs in the wall of the pipe.

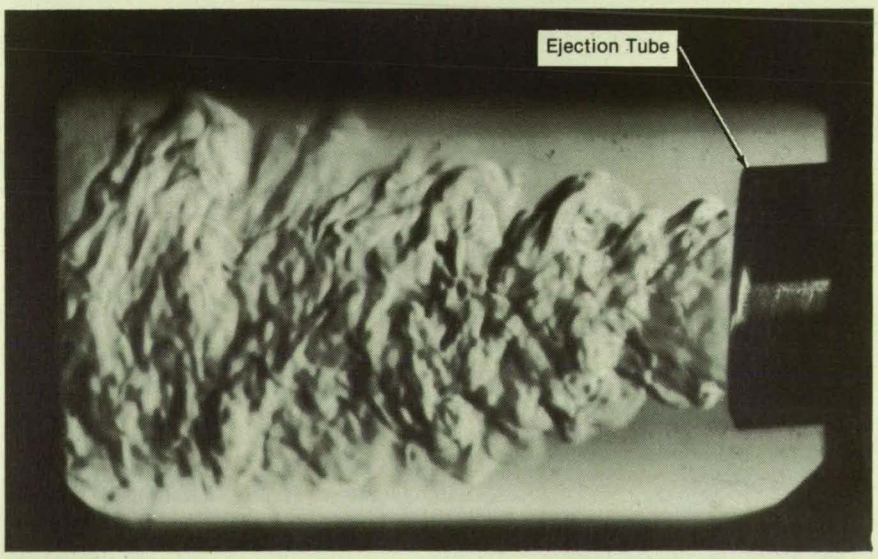


Figure 2. The **Flow of a Dense Chlorofluorocarbon Gas Into Air** in a glass pipe was photographed with the new schlieren system.

Because of residual refraction errors caused by the cylindrical components, the spot focused on the knife edge is smeared slightly in the direction perpendicular to the axis of the test cell. To avoid the effects of this smear, the knife edge in the new system must be oriented perpendicular to the axis of the test cell.

The cylindrical optical components introduce some lateral magnification, so that the final image appears slightly stretched in the direction perpendicular to the axis of the pipe. The ratio between the longitudinal

and lateral magnifications can be determined by placing a grid or other object of known dimensions in the tube and making appropriate measurements on the resulting schlieren image.

This work was done by Robert C. Costen, David B. Rhodes, and Stephen B. Jones of **Langley Research Center**. *For further information, Circle 74 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page ***18****]. Refer to LAR-13944.*

Optical Pseudocolor Encoding of Gray-Scale Image

Optical encoding is much faster than is digital electronic encoding.

NASA's Jet Propulsion Laboratory, Pasadena, California

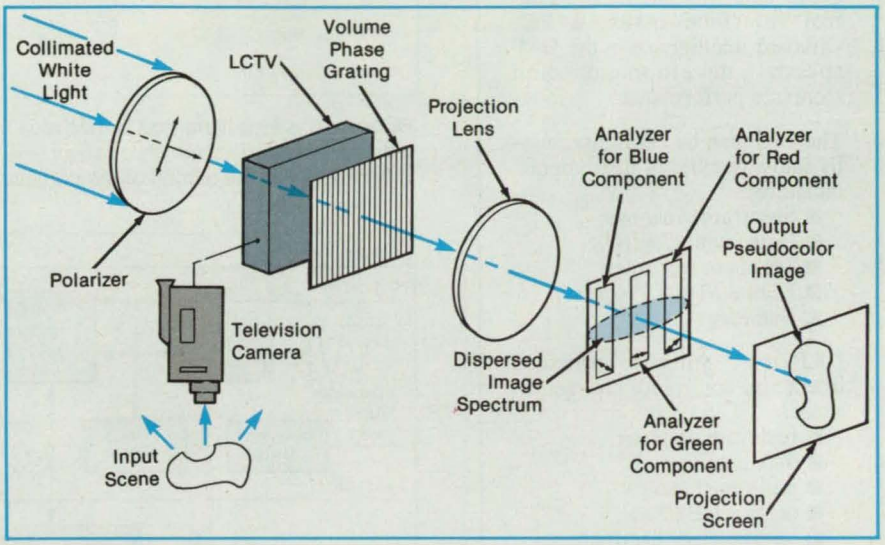
An experimental optical apparatus encodes a gray-scale image in pseudocolor. For such purposes as thermography, inspection of circuit boards, mammography, and mapping, it is advantageous to convert gray-scale images to pseudocolor because people can easily distinguish several thousand colors, whereas they can distinguish only about 20 shades of gray. Usually, pseudocolor is generated from gray by digital computer processing, which can impose significant delay between the reception and the display of the image. In contrast, the speed of the optical pseudocolor-encoding apparatus is limited only by the speed of the display device in it.

The apparatus (see figure) includes a liquid-crystal television display device (LCTV) without the usual attached polarizing screens. The LCTV is illuminated from behind by white light through an external polarizer. The polarization of light emerging from the LCTV is rotated from a nominal orientation (perpendicular to that of the polarizer) by an amount approximately proportional to the local brightness signal in the image in the LCTV. A volume phase grating near the LCTV disperses the light in this polarization image into red, green, and blue wavelengths. A projection lens forms a real image of the output plane of the LCTV on a projection screen.

An analyzer polarized perpendicularly to the nominal (zero-modulation) polarization is placed on the back focal plane of the lens, where it intercepts the blue component of the dispersed image spectrum. The light emerging from this analyzer has an intensity proportional to $\sin^2(\Omega)$, where Ω is the angle of rotation in the LCTV. Thus, the intensity of the blue pseudocolor component of the affected portion of the image increases with increasing brightness modulation in the affected portion of the image.

Another analyzer, placed to intercept the green spectrum, is polarized perpendicularly to the nominal polarization of light that emerges from the LCTV at maximum brightness modulation. The light emerging from this analyzer has an intensity proportional to $\sin^2(\Omega_{max} - \Omega)$, where Ω_{max} is the rotation in the LCTV at maximum brightness modulation. Thus, the intensity of the green pseudocolor component decreases with increasing brightness modulation.

A third analyzer placed to intercept the red spectrum is polarized perpendicularly to the bisector between the two extreme polarization states $\Omega = 0$ and $\Omega = \Omega_{max}$. The intensity of the output of this analyzer is proportional to $\sin^2(\Omega - \frac{1}{2}\Omega_{max})$; that is, in the red pseudocolor component, the midpoint of the gray scale is transformed to darkness, and the intensity increases as the brightness modulation departs (whether by rising above or falling below) from the midpoint. The outputs of the analyzers are combined on the projection screen, yielding a unique combination of red, green, and blue for each gray level in the original image.



In the **Optical Pseudocolor-Encoding Apparatus** the brightness modulation in the image from the television camera is transformed into polarization modulation in the LCTV, and then into pseudocolor modulation in the image on the projection screen.

This work was done by Tien-Hsin Chao and Hua-Kuang Liu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 75 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
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Mail Stop 305-6
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1201 East California Boulevard
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Refer to NPO-17764, volume and number of this NASA Tech Briefs *issue, and the page number.*

Measuring Response of Propellant to Oscillatory Heat Flux

A microwave Doppler velocimeter measures the motion of the combustion front.

NASA's Jet Propulsion Laboratory, Pasadena, California

An apparatus for research in the combustion of solid propellants measures the oscillatory response of the rate of burning to oscillating thermal radiation from a modulated CO_2 laser. The purpose of such measurements is to determine the response of

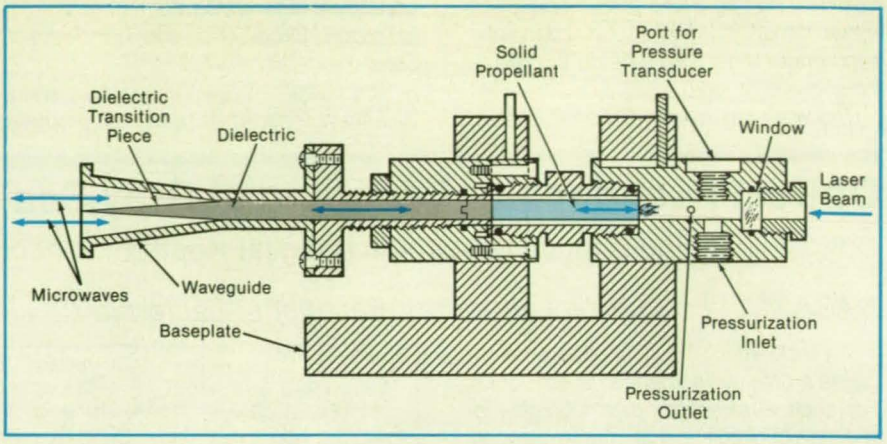


Figure 1. The **Propellant Rod** is irradiated from the left with microwaves and from the right with an infrared laser beam while its right face burns. The Doppler shift in the reflected microwaves is a measure of the motion of the combustion front.

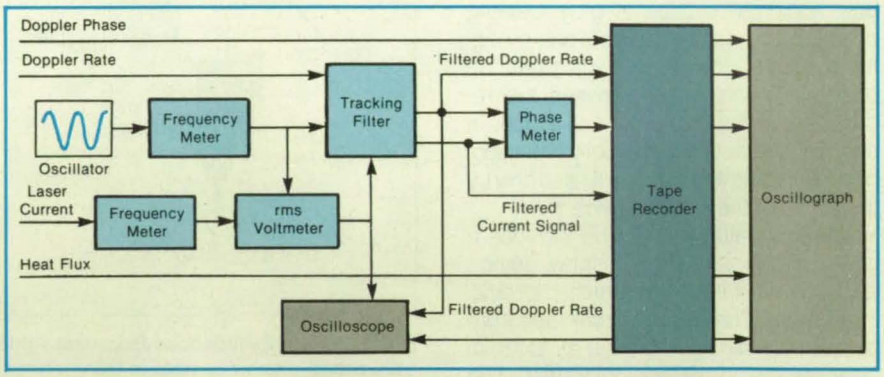


Figure 2. **Microwave, Laser-Current, and Heat-Flux Signals** are processed into and recorded in forms that are useful in determining the desired response of the propellant.

the rate of burning to an equivalent oscillation in pressure, which response is more difficult to measure because it is not always possible to generate pressure oscillations of sufficient amplitude. The measurements performed in the new apparatus are converted to the desired response to pressure via equations derived from the theory of combustion.

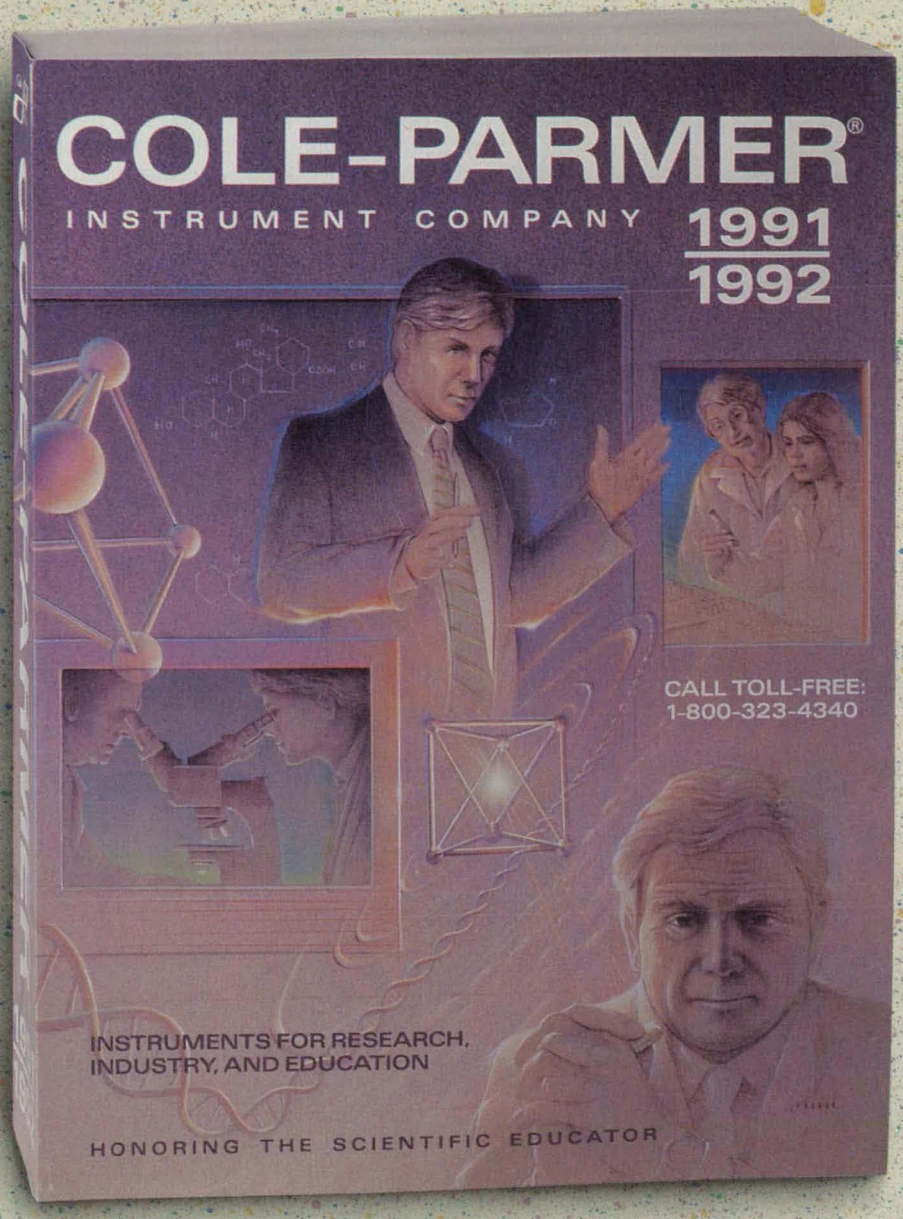
A rod of propellant is mounted in a burner assembly that includes a waveguide at one end and an infrared window at the other end (see Figure 1). A microwave Doppler velocimeter measures the motion of the combustion front. The microwaves enter the burner assembly via the waveguide and a dielectric transition piece, are guided along the unburned portion of the propellant to the combustion front, and are reflected back along the foregoing transmission path to the microwave apparatus. The microwave phase shift and rate of change of phase shift (Doppler rate) are measured to determine the position and speed, respectively, of the combustion front.

Meanwhile, the burning end of the propellant rod is thermally irradiated through the infrared window with the modulated laser beam. The duration and frequency of heat-flux pulses are monitored and adjusted by monitoring and adjusting the laser current. A tracking filter tuned to the laser-pulse frequency filters the laser-current signal and the oscillatory component of the Doppler shift. The difference between the phases of these two signals is measured and recorded. Also recorded are the mean Doppler phase shift, the pressure in the burner, and the heat-flux measurement from a calorimeter (see Figure 2).

Initial tests were performed on a propellant of a type that had also been tested by the modulated-pressure technique. The data showed a reduction in the amplitude of the Doppler phase shift with burn time, attributed to the attenuation of the radiant flux by the column of combustion-product gases growing in the burner. The absolute value and the argument of the burning-rate-response function were plotted as functions of frequency from 0 to 1 kHz, and the argument data show the same type of variations during individual burns as those observed in previous oscillatory-pressure measurements.

This work was done by Leon D. Strand, Ken Schwartz, and Shawn P. Burns of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 94 on the TSP Request Card.*
NPO-17428

Instruments for Industry, Research, and Education



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Nondestructive Technique To Assess Embrittlement in Steels

Magnetoacoustic emission associated with reversible motion of magnetic domain walls is measured.

Langley Research Center, Hampton, Virginia

Temper embrittlement is the loss of impact toughness that occurs in susceptible alloy steels when they are heated within, or slowly cooled through, the temperature range of 350 to 575 °C. This phenomenon is encountered primarily during postfabrication heat treatment like that performed to relieve residual stresses. Temper embrittlement in such steels as HY80 has been given considerable attention because of the extensive use of such steels and the continuing trends toward components required to have high yield strength and high impact toughness. Currently, the measurement of temper embrittlement involves extensive destructive mechanical testing. There is a need for a nondestructive technique to detect the loss of impact toughness by temper embrittlement in steels.

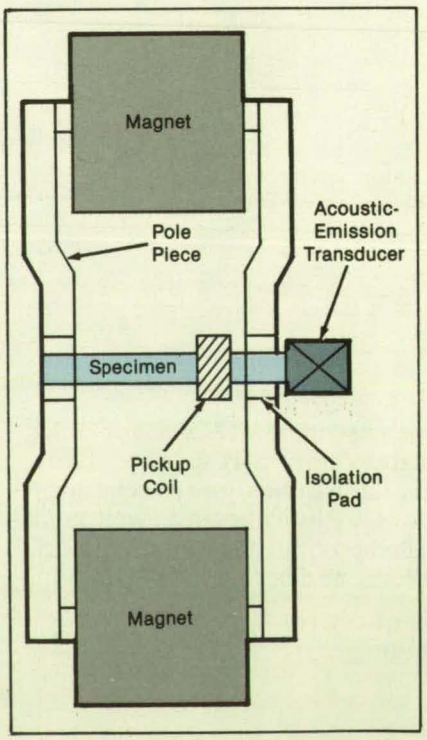
Recent research at NASA Langley Research Center led to identification of a nondestructive technique for the detection of temper embrittlement in HY80 steel. The technique measures magnetoacoustic emission associated with reversible motion of domain walls at low magnetic fields. A preliminary mathematical model depicts grain boundaries as obstacles to the motion of domain walls. Because of the segregation of particular constituent elements (including certain impurities) at grain boundaries, embrittled steel offers greater obstacles to the motion of the walls of magnetic domains than do steels that are not embrittled.

The figure shows the test configuration with magnetic field applied to the specimen, a pickup coil that detects the level of the magnetic field in the specimen, and an ultrasonic acoustic-emission transducer. An alternating magnetic field is applied to the specimen, and the acoustic-emission transducer detects the acoustic emission generated by the changing magnetic field. The resulting magnetoacoustic data are separated into pulse-height categories to form a histogram. The histogram for the unembrittled steel is subtracted from that for an embrittled steel. The difference in enclosed area is correlated with the amount of embrittlement.

The prediction of the mathematical model and the results of experiments indicate that magnetoacoustic emission in embrittled steels is greater and qualitatively different from that in steels that are not embrittled. This technique should be of interest to engineers who are responsible for the reliability and safety of various dynamically loaded and/or thermally cycled steel parts. Applications include the testing of landing gears, naval vessels, and parts subjected to heat, such as those found in steam-pipe fittings, boilers, turbine rotors, and nuclear pressure vessels.

This work was done by Sidney G. Allison, William T. Yost, and John H. Cantrell of **Langley Research Center**. *For further information, Circle 7 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 18]. Refer to LAR-13817.



The **Acoustic-Emission Transducer** detects the acoustic emissions generated by the alternating magnetic field.

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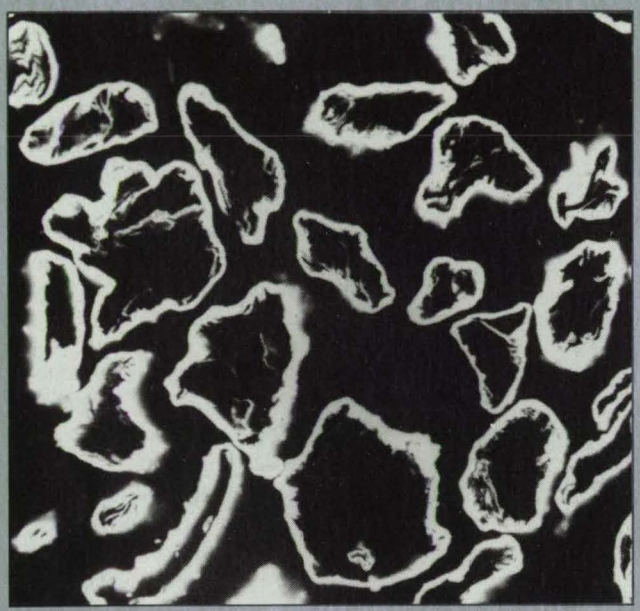
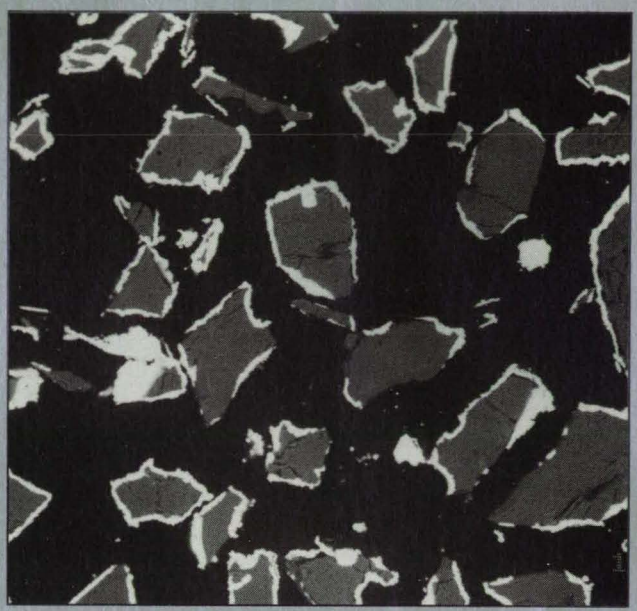


Nickel Coated Graphite Powders



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APPLICATIONS

New uses for INCO SPP Coated Products include conducting film technology, electronics packaging, EMI shielding, electronic detection devices, controlled heating systems, hard metals and powder metallurgy parts.

RESEARCH

INCO SPP research activities for this line of products include nickel carbonyl coated powders and other substrates. Applications include advanced products for EMI shielding, ESD, arc welding, powder metallurgy additives, and in battery technologies.

One highly interesting area of research is in the area of electronic detection. Coated products are being combined with paint for highway divider strips and as ink in bar codes for vehicle identification. This could provide an accurate measure of automobile speed on those highways. Another futuristic consideration is "computer trips for cars" using those strips and bar codes to program automotive travel and identification.

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Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Radiative Processes in Air Excited by an ArF Laser

Studies are directed toward the use of fluorescence to measure temperature.

A report describes experimental and theoretical studies of the emission spectrum of air excited by light from an ArF laser. The purpose of the studies was to determine the conditions under which fluorescence from O_2 could be used to measure temperatures in aerodynamic flows.

In the proposed laser-induced fluorescence technique, laser radiation at a wavelength of 193 nm would be used to excite selectively one or more rotational transitions in the Schumann-Runge

$$(B^3\Sigma_u^- - X^3\Sigma_g^-)$$

band of O_2. The intensity of the resulting fluorescence should be proportional to the population density of the ground state, which in turn is sensitive to the temperature of the air.

In the experiments, the emission from the focal region of the laser beam was collected in a direction perpendicular to the axis of the beam, focused on the entrance slit of a grating monochromator, and detected by a photomultiplier. The spectral analysis was confined to emission at wavelengths below 260 nm to avoid fluorescence in most window materials. By a theoretical calculation that incorporated the spectral distribution of the incident laser beam, the observed fluorescence spectrum was corrected for the absorption of the laser radiation by air along the beam (that is, not in the focal region).

In addition to the expected fluorescence from O_2, the emission spectrum was found to include significant contributions from the near-resonant Raman fundamental and overtone bands. In a conceptual temperature-measuring system that was uniformly efficient over the spectral range of interest, the Raman radiation would dominate the spectrum, thereby reducing the sensitivity of the system to the temperature. Therefore, in a practical system, one might prefer to filter the spectrum to remove the Raman contributions.

The fluorescence spectrum was also found to contain four-photon fluorescence excitation of carbon produced from atmospheric CO_2 and three-photon excitation of O_2^+. The interference of these effects with fluorescence measurements of tempera-

ture could be reduced very simply by reducing the intensity of the incident laser beam.

This work was done by Robert L. McKenzie and Winifred Huo of **Ames Research Center** *and Gabriel Laufer of ANALATOM, Inc. To obtain a copy of the report, "Radiative Processes in Air Excited by an ArF Laser," Circle 153 on the TSP Request Card. ARC-12136*

More About Evaporation in Clusters of Drops

Several mathematical models are used to study transport of species, mass, and heat.

A report presents a theoretical study of evaporation in clusters of spray drops in liquid fuel. The report is related to the reports described in "Turbulence and Evaporation in Clusters of Drops" (NPO-17323) and "Effects of Turbulence on Ignition" (NPO-17335), *NASA Tech Briefs* Vol. 13, No. 10, pages 45 and 46. The purpose of this study is to improve the theoretical description of the transport of molecular species, mass, and heat between a cluster and its surroundings.

The study involves two similar mathematical models of the cluster and its interactions. In both cases, there is assumed to be a spherical cluster of spherical drops (all of the same size) of a single-component liquid. The cluster is assumed to move axially as an entity through an ambient gas, which is at a temperature higher than that of the drops and at constant pressure. The drops move radially in the cluster in a self-similar manner that preserves the uniform distribution. Each drop of the cluster is considered to be surrounded by a fictitious sphere of influence, the radius of which is half the distance between the centers of two adjacent drops.

Both models take account of the transfers of momentum, species, mass, and heat between the liquid and gaseous phases within the cluster and between the cluster and the ambient gas. The exchange of momentum is due to evaporation and two drag forces: one for the individual drops and one for the cluster as an entity. To calculate the transport of mass, species, and heat from the cluster to the surroundings, the first model of the cluster ignores the radial velocity and uses an ad hoc "trapping factor," which is a weighting factor that represents situations intermediate between those of dilute clusters, wherein mass is assumed trapped, and dense clusters, from which mass is assumed to escape to ambient. In the second model of the cluster, the transport can be calculated explicitly, without assuming a trapping factor, because in this model, both the drops and the gas are considered to have self-similar radial velocities.

Two models of turbulence are used to calculate the transport of mass, species, and heat from the surroundings. In turbulence model 1, turbulence is assumed to build up with time as the axial velocity of the gas inside the cluster increases and the relative axial velocity between the drop and gas decreases correspondingly. In turbulence model 2, turbulence is assumed to be present initially.

The numerical results of both models show that transport processes are unimportant for dilute clusters but become crucial for dense clusters of drops. The results also show that transport processes are more important for smaller clusters of drops in the dense regime. Although the qualitative behavior of the two cluster models is similar, substantial quantitative discrepancies appear in the dense-cluster regime. The authors suggest that comparisons of global models like these with experimental data on evaporation times in the dense-cluster regime would be helpful in the evaluation and improvement of the models.

The numerical results also show that the fuel-loss ratio depends strongly on the size of the cluster and the model of turbulence, whereas the total loss of mass is nearly insensitive to turbulence except in the case of small clusters. Overall, the numerical trends show that global cluster models like these look promising because, despite their simplicity, they account at least semiquantitatively for the major physical phenomena in the evaporation of sprayed liquid fuels.

This work was done by Josette Bellan and Kenneth G. Harstad of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Transport-Related Aspects of Dense Spray Evaporation," Circle 2 on the TSP Request Card. NPO-17594*

Electrostatic Dispersion of Drops in Clusters

Electrical charging can speed evaporation.

A report presents a theoretical study of the evaporation and dispersion of electrostatically charged clusters of drops in liquid fuel sprays. The report represents an extension of the studies described in the preceding article, "More About Evaporation of Drops in Clusters" (NPO-17594). This study was undertaken in an effort to learn how electrostatic atomization can be used to disperse fuel better in order to reduce the formation of soot in diesel engines and other power and combustion systems.

Except for the addition of electrostatic effects, the mathematical model of the cluster of drops is the same as in the study described in the preceding article. Calculations based upon this model are made for charged as well as uncharged clusters of

drops. The charge is varied from zero to the maximum possible charge found empirically in hydrocarbon sprays. The two models of turbulence mentioned in the preceding article are also used.

The models are used to perform a numerical simulation for n-decane drops evaporating in air under conditions representative of those in a combustor. Although the model of the cluster does not pertain directly to conditions in diesel chambers, in that it includes the assumption of atmospheric pressure, it nevertheless provides valuable insights into some of the fundamental differences between the behaviors of charged and uncharged drops.

The results of the simulation show that in the dense-cluster regime, the evaporation of the drops can be speeded considerably by electrostatic charging and that turbulence affects the rate of evaporation much less than does electrostatic charge. The results for the dilute-cluster regime show that turbulence does not have much of an effect on evaporation, whether or not electrostatic charge is present, but that the loss of fuel vapor from the cluster can be speeded by an increase in turbulence and decreases in the size of the cluster and/or in electric charge.

Calculations pertaining to soot are not performed. Instead, the authors draw inferences regarding the impact of electrostatic charge on the control of soot in heterogeneous flames, based on the prior experimental data on soot formation in well-defined sprays.

This work was done by Josette Bellan and Kenneth G. Harstad of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Electrostatic Dispersion of Drops in Clusters," Circle 80 on the TSP Request Card.*
NPO-17516

Preliminary Analysis of Data From AVIRIS

Radiometric calibration in flight and determination of reflectance of the ground are discussed.

A report presents a preliminary analysis of the performance of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), a scanning instrument that produces images at wavelengths from 400 to 2,450 nm. The AVIRIS includes four spectrometers connected by optical fibers to a common set of foreoptics. The analysis focuses upon the calibration of the instrument and determination of the reflectance of the surface of the Earth from its measurements.

The purposes of this study were (1) to develop in-flight spectral and radiometric calibrations for the instrument and (2) to compare various empirical and theoretical methods of compensating for the effect of the atmosphere in recovering the spectral reflectance of the surface from radiances measured by the instrument at altitude. For these purposes, the following data (in addition to the AVIRIS data) were obtained:

- Optical depth of the atmosphere from measurements with solar radiometers;
- The ratio of diffuse to direct incident light at the surface of the Earth from measurements with a hand-held radiometer;
- The total precipitable water from measurements with a ratioing spectral hygrometer; and
- Spectral reflectances of a bright playa surface, a dark runway, and a concrete tarmac from measurements with a portable spectrometer ordinarily used to estimate average reflectances of calibration targets.

To meet the calibration objective, the radiance calculated from AVIRIS data taken while viewing the bright playa target was determined according to the responsivities of the AVIRIS measured in a laboratory, then compared with the radiance of that target as measured on the ground and corrected by the LOWTRAN 6 mathematical model of the transmittance and reflectance of the atmosphere. The model includes a catalog of strengths and wavelengths of atmospheric absorption bands, which were used as references to check

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the wavelength calibration and spectral resolution of the AVIRIS.

To meet the spectral-reflectance objective, the reflectances of the playa and runway were taken together with the spectral responses of the AVIRIS to develop linear empirical equations, which were then used to predict the reflectance of the tarmac. Next, using the runway as a spectrally flat reference, an equivalent reflectance of the tarmac was computed from the ratios of the radiances of the tarmac to those of the runway as measured by the AVIRIS. Finally, the radiances derived from the AVIRIS data, corrected by the LOWTRAN 6 model, were used to invert the model and recover the reflectance of the surface.

The comparisons between in-flight radiances, predicted from the laboratory calibration, and radiances generated by the atmospheric model for flight conditions showed apparent agreement to within a few percent at wavelengths from 1,800 to 2,450 nm. Between 600 and 1,800 nm, the response of the AVIRIS was found to be systematically low by as much as 70 percent, and between 400 and 600 nm, it was found to be higher than expected. These observations are tentatively traced to thermal distortions of the instrument, and to detachment, during flight, of optical fibers to two of the spectrometers. Of the three tested methods for calculating the reflectance of the surface, the best one proved to be the first (empirical) one.

This work was done by James E. Conel, Gregg A. Vane, Robert O. Green, Ronald E. Alley, Veronique Carrere, Carol J. Bruegge, of Caltech and Andy Gabell of CSIRO, Perth, Australia for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Airborne Visible/Infrared Imaging Spectrometer (AVIRIS): Inflight Radiometric Calibration and the Determination of Surface Reflectance," Circle 97 on the TSP Request Card.*
NPO-17622

Temperature Dependence of Single-Event Effects

In most cases examined, vulnerability to these effects increased or remain constant with temperature.

A report describes an experimental study of the effects of temperature on the vulnerability of integrated-circuit memories and other electronic logic devices to single-event effects — spurious bit flips or latch-up in logic state caused by impacts of energetic ions. The study involved the analysis of data on 14 different device types. (Some types were nominally identical but made by different manufacturers.) The data were taken both from experiments performed by the authors for this purpose and from experiments performed previously by other authors.

In some instances, there are sufficient data to generate graphs. In others, only a narrative is possible because only two temperature data points are available. With the exception of one complementary metal oxide/semiconductor static random-access memory, the vulnerability of each device was found to increase or remain constant with increasing temperature, although to a different degree for each device. Further, with the exception of one instance in one of the previous studies, lowering the temperature was found to decrease the vulnerability. In this one instance, the temperature was lowered so far that the device lost its functionality.

This work was done by James R. Coss, Donald K. Nichols, Lawrence S. Smith, Mark A. Huebner, and George A. Soli of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Temperature Dependence of Single Event Phenomena," Circle 24 on the TSP Request Card.*
NPO-17870

Materials

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Delamination Analysis of Composite Curved Bars

A theory predicts the location and magnitude of the delamination stress.

One of the major causes of stiffness and strength degradations in laminated composite structures is the delaminations between composite layers. In most engineering applications, laminated composite structures have certain curvatures and, therefore, are subject to potential delamination problems during service (cyclic bending loadings). One of the most appealing geometries of a test coupon for studying the composite delamination phenomenon is the semicircular curved bar shape (C-coupon). When such a test specimen is subjected to end forces, the peak radial stress and the peak shear stress induced in the curved bar will be identical in magnitudes but are out of phase in the tangential direction by $\pi/2$. Namely, the peak radial stress is located at the midspan point of the semicircular curved bar, but the peak shear stresses occur at both ends of the semicircular curved bar. The radial distance of both the peak radial stresses and the peak shear stresses are exactly the same. The above nature of the semicircular curved bar offers an excellent situation for studying the initiation and subsequent propagation of delamination zones (open-mode or shear-mode) under cyclic loadings and for studying the fatigue behavior (degradation of stiffness and strength) of multilayered composite materials.

The classical anisotropic elasticity theory was used to construct a "multilayer" composite semicircular curved bar subjected to end forces and end moments. The radial location and intensity of the open-mode delamination stress were calculated and were compared with the results obtained from the anisotropic continuum theory and from the finite element method. The multilayer theory gave more accurate predictions of the location and the intensity of the open-mode delamination stress than those calculated from the anisotropic continuum theory. The "multilayer" theory developed is currently being applied to predict the open-mode delamination stress concentrations in horse-shoe-shaped composite test coupons.

This work was done by William L. Ko and Raymond H. Jackson of **Ames Research Center**. *Further information may be found in NASA TM-4139 [N90-12669], "Multilayer Theory for Delamination Analysis of a Composite Curved Bar Subjected to End Forces and End Moments."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
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Computer Programs

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Materials

Calculating the Resistivity of a Deposited Film

An iterative procedure computes the resistivity from measurements by the four-probe method.

A computer program and technique have been developed to aid in the solution of the class of problems in which measurements of the electrical resistivity are needed for a substance deposited on a substrate of higher resistivity than the deposited layer.

One of the ways in which a semiconductor material is characterized is by measurement of its resistivity. In the development of silicon carbide (SiC) for use as a semiconductor material for applications at high temperatures, it became necessary to measure the resistivity of the thin SiC film while it was still attached to the silicon upon which it had been grown epitaxially. The problem is that the presence of the silicon substrate introduces an error in the measured resistivity of the SiC. A method of calculating the "true" resistivity of the deposited layer on a substrate of finite and different resistivity has been discussed by various authors. The present technique results from amplification and clarification of that previous work.

Four probes equally spaced along a line make contact with the deposited layer. A current of magnitude I is injected and withdrawn via the two end probes, and the voltage V between the two intermediate probes is measured. The unknown conductivity, σ_1, or resistivity, ρ_1, of the deposited film is to be determined in terms of the known quantities V/I, the thickness, ω_1, of the deposited layer, the thickness, ω_2, of the substrate, and conductivity, σ_2, of the substrate. The four-point probe is used to obtain σ_2 before deposition. The thicknesses of the deposited layer and substrate can be measured independently.

Starting from basic principles, an ex-

pression for the ratio *V/I* is developed. This expression involves the probe spacing, *s*, the relative thicknesses of the layers, and the substrate resistivity as parameters, as well as the unknown resistivity of the deposited layer. The unknown resistivity is found by using the computer program to evaluate the theoretical expression iteratively.

This program was written by Lawrence G. Oberle and Gustave C. Fralick of **Lewis Research Center**. *For further information, Circle 71 on the TSP Request Card.*
LEW-14389

Finite-Element Composite-Analysis Program

The behavior of a composite can be analyzed on a microcomputer.

Advanced composite materials have gained use in the aerospace industry during the last 20 years because of their high specific strengths and stiffnesses and low coefficients of thermal expansion. The design of composite structures requires the analysis of the behaviors of composite materials. The Finite Element Composite Analysis Program, FECAP, is a special-purpose finite-element program for analyzing the behavior of a composite material with a microcomputer. For the purpose of this program, a composite material is defined as the combination of at least two distinct materials to form one nonhomogeneous anisotropic material. FECAP is based in part on the assumption of a state of generalized plane strain in a material consisting of two or more orthotropic phases and subjected to mechanical and/or thermal loading.

The finite-element formulation used in FECAP is based on displacement and requires the minimization of the total potential energy for each element with respect to the unknown variables. This procedure leads to a set of linear simultaneous equations relating the unknown nodal displacement to the applied loads. The equations for each element are assembled into a global system, the boundary conditions are applied, and the system is solved for the nodal displacements. The analysis can be performed using either four-node linear or eight-node quadratic isoparametric elements. The output includes the nodal displacements and the stresses and strains in the elements.

FECAP was written for a Hewlett-Packard HP9000-Series 200 microcomputer with the HP Basic operating system. It was written in HP BASIC 3.0 and requires approximately 0.5 Mbytes of random-access memory in addition to what is required for the operating system. A math coprocessor card is highly recommended. FECAP was developed in 1988.

This program was written by David E. Bowles of **Langley Research Center**. *For further information, Circle 88 on the TSP Request Card.*
LAR-14109

Calculating Masses, Densities, and Compositions of Alloys

Three simple computer programs perform routine metallurgical calculations.

The Metallurgical Programs include three simple programs that calculate solutions to problems common to metallurgical engineers and persons making metal castings. The first program calculates the mass of a binary ideal mixture (alloy), given the weight fractions and densities of the pure components and the total volume. The second program calculates the densities of a binary ideal mixture. The third program converts the atomic percentages of a binary mixture to weight percentages. The programs use simple equations to assist with routine calculations.

The Metallurgical Programs are written in Microsoft QuickBASIC for interactive execution and have been implemented on an IBM PC-XT/AT operating on MS-DOS 2.1 or higher with 256 Kbytes of memory. All in-

structions needed by the user appear as prompts as the software is used. Data are entered by use of the keyboard only, and output is via the monitor. The Metallurgical Programs were written in 1987.

This program was written by H. de Groh for **Lewis Research Center**. *For further information, Circle 10 on the TSP Request Card.*

LEW-14914

Mechanics

Code for Analysis of Wing-and-Flap Systems

Effects of leading- and trailing-edge flaps are included.

The SUBAERF2 program was developed to provide for the analysis of the subsonic aerodynamics and the design by iteration of low-speed wing/flap systems. SUBAERF2 is based on a linearized-theory lifting-surface solution but also accounts for some nonlinear characteristics. It is particularly well suited to configurations that, because of the requirements of high-speed flight, must employ thin wings with highly swept leading edges. The program is applicable to wings with either sharp or rounded leading edges. This program is a new and improved version of the programs described in LAR-13116 and LAR-12987, and replaces both of them.

The low-speed-aerodynamic-analysis method used in SUBAERF2 provides estimates of wing performance that include the effects of attainable leading-edge thrust and vortex lift associated with leading-edge flow separation. The basic aerodynamic-analysis method has been improved to provide for the convenient, efficient, and accurate treatment of simple leading-edge and trailing-edge flap systems. The user puts in the flap geometry directly. Solutions can be found for various combinations of deflections of leading- and trailing-edge flaps. The program provides for the simultaneous analysis of up to 25 pairs of schedules of deflections of leading-edge and trailing-edge flaps.

The SUBAERF2 program is written in FORTRAN V for batch execution and has been implemented on a CDC 175 computer operating under NOS 2.4 with a central-memory requirement of approximately 115K (octal) of 60-bit words. This program was originally developed in 1983 and later revised in 1988.

This program was written by Christine M. Darden of **Langley Research Center** *and Harry W. Carlson of Planning Research Corp. For further information, Circle 62 on the TSP Request Card.*

LAR-13994

Wing-Design and -Analysis Code

The new version features improved numerical accuracy and additional capabilities.

The WINGDES2 computer program provides a wing-design algorithm based on a modified linear theory that takes into account the effects of attainable leading-edge thrust. A primary objective of the WINGDES2 approach is the generation of a camber surface as mild as possible to produce drag levels comparable to those attainable with full theoretical leading-edge thrust.

WINGDES2 provides an analysis as well as a design capability and is applicable to both subsonic and supersonic flow. The optimization can be carried out for such designated portions of a wing as leading-and trailing-edge areas, for the design of mission-adaptive surfaces, or for an entire planform such as that of the wing of a supersonic transport airplane.

This program replaces an earlier wing-design code designated WINGDES (see LAR-13315). The new version incorporates modifications to improve numerical accuracy. It also provides additional capabili-

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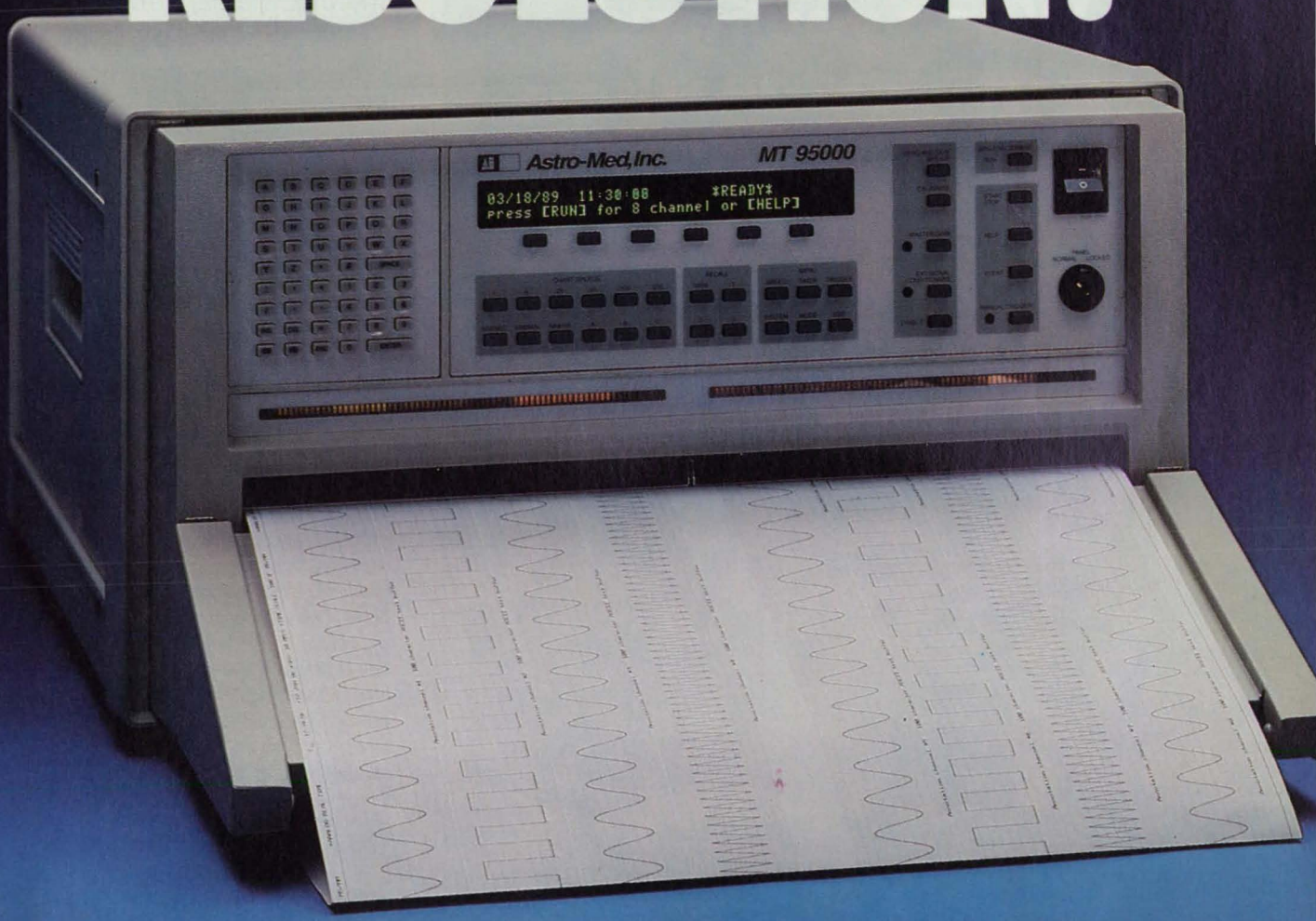

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ties, including a means of accounting for the presence of interference pressure fields from airplane components other than the wing, and a direct process for selection of flap surfaces to approach the shape performance levels of the optimized wing surfaces.

WINGDES2 determines an optimum combination of a series of candidate surfaces rather than the more-commonly-used candidate loadings. The objective of the design is the recovery of unrealized theoretical leading-edge thrust of the input surface by shaping of the design surface to create a distributed thrust and thus minimize drag. The input consists of airfoil-section-thickness data, leading- and trailing-edge geometry, spanwise and chordwise station information, and such operational parameters as mach and Reynolds numbers, the angle of attack, and the number of camber surfaces. The output includes optimized camber-surface ordinates, pressure-coefficient distributions, and theoretical aerodynamical characteristics.

WINGDES2 is written in FORTRAN V for batch execution and has been implemented on a CDC CYBER 175 computer operating under NOS 2.4.3 with a central-memory requirement of approximately 167K (octal) of 60-bit words. This program was developed in 1984 and was last updated in 1988.

This program was written by Christine M. Darden of **Langley Resarch Center** *and Harry W. Carlson of Planning Research Corp. For further information, Circle 61 on the TSP Request Card.*
LAR-13995

Machinery

Capillary Pumped Loop Modeler

This program simulates the thermodynamic performance of capillary pumped loops.

The Capillary Pumped Loop (CPL) Modeler computer program is an amalgamation of software that mathematically models the performance of a CPL system and its environment. A CPL is a two-phase heat-transport device capable of transferring heat loads efficiently over a large distance with little temperature differential. It utilizes the surface-tension forces established in a fine-pore capillary wick to circulate the working fluid, thus requiring no external pumping power.

This program predicts the steady-state or quasi-steady behavior of a CPL embedded in a spacecraft or other thermal environment. It also predicts the location of the liquid/vapor interface in each condenser. The program calculates the pressure drops due to flow losses in various flow regimes including laminar, transition, and low- and high-Reynolds-number turbulent flows. The effects of subcooling on the liquid returning to the evaporator and of reverse flows in the evaporator associated with the sharing of heat loads are accounted for. The user can include multiple parallel evaporators and condensers. Thermodynamic properties of 20 fluids — including water, ammonia, propane, and propylene — are included in a library.

The modeler creates SINDA statements that describe the CPL from the parameters entered by the user into a user-friendly interface program. These statements are then combined with an environment the user generates in SINDA to create a complete analytic model of CPL. The operation of the CPL is then simulated as the merged input file is executed in SINDA.

The CPL modeler runs interactively on a VAX computer under VMS 4.4 or greater and is written in VAX/VMS FORTRAN 77. TAE (COSMIC program GSC-13017) executable is included on the tape. SINDA (COSMIC program MSC-20891) is included in this package but may not work in all versions. Process quota must be at least 20,000 and possibly higher. This program

was developed in 1986.

This program was written by Jentung Ku and Elliot Itkin of OAO Corp. and Russell B. Schweickart and Laura Ottenstein of **Goddard Space Flight Center**. *For further information, Circle 23 on the TSP Request Card.*
GSC-13145

Mathematics and Information Sciences

Communication-Gateway Software for NETEX, DECnet, and TCP/IP

This software supports transfers of data between application programs on different computers.

The communications gateway software, GATEWAY, provides process-to-process communication between remote applications programs in different protocol domains. Communicating peer processes may be resident on any paired combination of NETEX, DECnet, or TCP/IP hosts. The gateway provides the necessary mapping from one protocol to another and facilitates practical intermachine communications in a cost-effective manner by eliminating the need to standardize on a single protocol or to implement multiple protocols in the host computers.

The purpose of the gateway is to support transfers of data between application programs on different host computers that use different protocols. The gateway computer must be physically connected to both host computers and must contain the system software needed to use the communication protocols of both host computers.

The process of communication between application partners can be divided into three phases: establishment of the session, transfer of data, and termination of the session. The communication protocols supported by GATEWAY have addressing mechanisms that enable an application to identify itself and distinguish among other applications on the network. The exact form of the address varies, depending on whether an application is passively offering (awaiting the receipt of a network connection from another network application) or actively connecting to another network.

When the gateway is started, GATEWAY reads a file of pairs of addresses. One of the addresses in a pair is used by GATEWAY for passively offering on one network while the other address in the pair is used for actively connecting on the other network, establishing the session. Now the two application partners can send and receive data in a manner appropriate to their home networks.

GATEWAY accommodates full duplex transmissions. Thus, if the application partners are sophisticated enough, they can send and receive simultaneously. GATEWAY also keeps track of the number of bytes contained in each transferred packet of data. If GATEWAY detects an error during the transfer of data, the sessions on both networks are terminated, and the passive offer on the appropriate network is reissued.

After performing the desired transfer of data, one of the remote applications sends a "network disconnect" to the gateway to close its communication link. Upon detecting this "network disconnect," GATEWAY replies with its own "disconnect" to ensure that the network connection has been fully terminated. Then GATEWAY terminates its session with the other application by severing the communication link.

GATEWAY has been implemented on a DEC VAX computer under VMS 4.7. It is written in Ada and has a central-memory requirement of approximately 406K bytes. The communications protocols supported by GATEWAY are Network Systems Corporation's Network Executive (NETEX), Excelan's TCP/IP, and DECnet. GATEWAY was developed in 1988.

This software was developed by B. Keith of **Goddard Space Flight Center** *and written by D Ferry and E. Fendler of Computer Science Corporation. For further information, Circle 60 on the TSP Request Card.*
GSC-13236

Program Manipulates Plots for Effective Display

Plots can be displayed in a variety of useful ways.

The Windowed Observation of Relative Motion (WORM) computer program is primarily intended for the generation of simple X-Y plots from data created by other programs. It enables the user to label, zoom, and change the scales of various plots. Three-dimensional contour and line plots are provided, but with more limited capabilities. The input data can be in binary or ASCII format, but all data must be in the same format. A great deal of control over the details of the plot is provided, such as gridding, the size of tick marks, colors, log/semilog capability, time tagging, and multiple and phase-plane plots. Many color and monochrome graphics terminals and hard-copy printer/plotters are supported.

The executive commands, menu selections, and macro files of WORM can be used to develop plots and tabular data, query the WORM Help library, retrieve data from input files, and invoke VAX DCL commands. Plots generated by WORM are displayed on local graphics terminals and can be copied by use of standard hard-copy capabilities. The graphics features of WORM include the following: zooming and dezooming various portions of the plot; documentation of the plot, including labeling of curves and listing of functions; multiple curves on the same plot; windowing of multiple plots and insets of the same plot; displaying a specific point on a curve; and spinning the curve left, right, up, and down for three-dimensional contour plots.

WORM is written in PASCAL for interactive execution and has been implemented on a DEC VAX computer operating under VMS 4.7 with a virtual-memory requirement of approximately 392K of 8-bit bytes. It uses the QPLOT device-independent graphics library, which is included with it. Full WORM graphics capabilities are supported for various Tektronix 40XX and 41XX terminals and PC and Macintosh terminal emulators. WORM was developed in 1988.

This program was written by F. Bauer and J. Downing for **Goddard Space Flight Center**. *For further information, Circle 79 on the TSP Request Card.*
GSC-13232

Mechanics

Mechanized Fluid Connector and Assembly Tool

Connections can be made or broken in confined spaces and with small external forces.

Lyndon B. Johnson Space Center, Houston, Texas

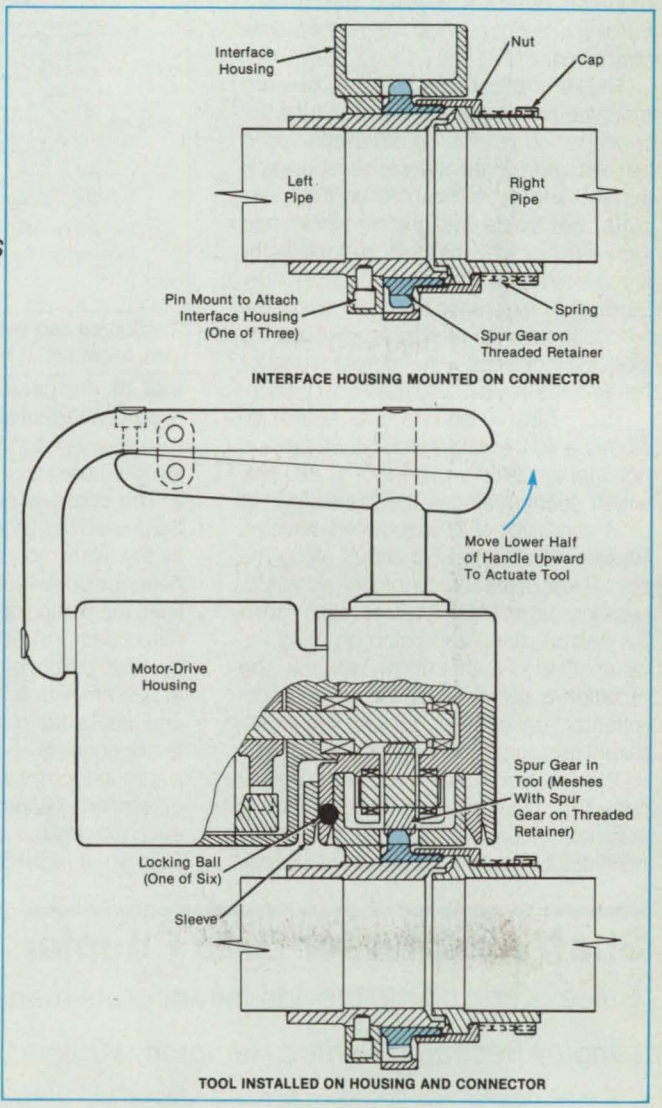
A modified union-type pipefitting can be tightened or loosened by a special power tool designed for use with it. Intended for the assembly of pipes in the proposed Space Station, the tool and fitting could also be used on Earth to make or break plumbing connections in crowded utility runs or other confined spaces where wrenches cannot be turned, where the forces exerted by wrenches might cause damage, or where the lack of a good grip prevents the technician from exerting sufficient torque on the connector.

In the new tool-and-connector system, it is necessary to have access to only one side of the pipe, and even then access can be offset from the centerline. Thus, it is possible to work in crowded piping troughs. The only external forces that need be applied are the relatively gentle ones incidental to the placement of the tool on the connector. The major forces and torques on the mating parts of the connector are generated within, and reacted through, the tool.

An interface housing — essentially, a receptacle for the tool — is placed on one member of the connector (the left member in the figure). Through a hole on the inner end of the interface housing, the tool has access to a spur gear fitted onto an externally threaded retainer that turns on this member. This retainer mates with a spring-loaded nut on the other member (the right member in the figure). The nut can rotate freely until the tool is installed.

One end of the tool mates with the interface housing. It is locked onto the housing by locking balls that are pushed by a sleeve into spherical recesses on the outside of the housing. A high-torque harmonic-drive gearmotor turns a spur gear that meshes with the one on the retainer. The gearmotor tightens or loosens the connector by turning the threaded retainer while the nut is held stationary. The drive train includes a free-play clutch to enable the initial meshing of gears. An impact-drive feature in the clutch overrides the normal electronic torque-limiting function and is used for disconnection.

The installation of the tool on the connector involves a sequence of relatively simple, highly tactile steps. There is no need for precise, visual alignment or inspection. This sequence is an important feature of the tool-and-connector concept, making it adaptable to telerobotic operation.



The **Tool Turns a Spur Gear** on an externally threaded retainer on the left member of the connector. The retainer engages a nut on the right member of the connector.

This work was done by Ronald C. Zentner and Steven A. Smith of Boeing Aerospace Co. for **Johnson Space Center**. *For further information, Circle 34 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 18]. Refer to MSC-21434.

Monitoring Small Deformations in an Instrument

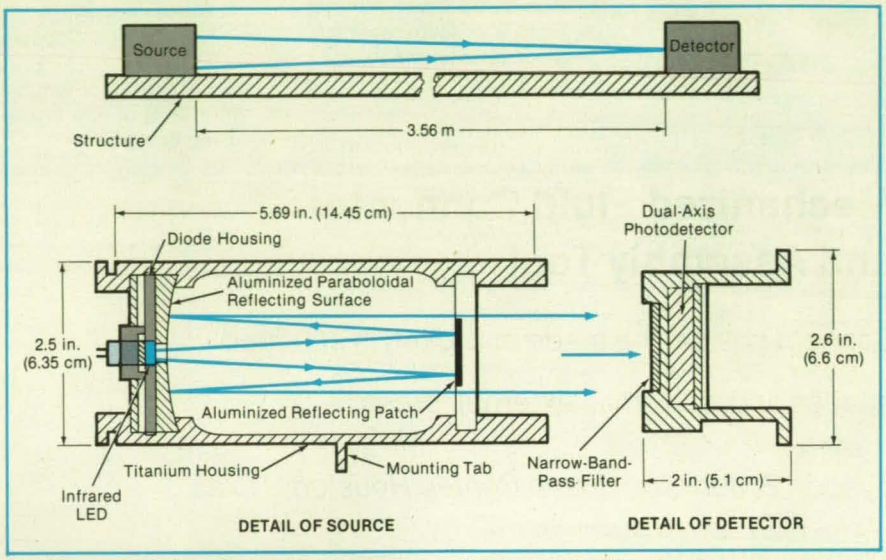
Relatively simple source/detector pairs measure changes that affect optical alignment.

Goddard Space Flight Center, Greenbelt, Maryland

A system for monitoring small thermal, gravitational, and dynamical deformations in an x-ray telescope includes two sources of infrared light, each associated with a dual-axis, position-sensing photodiode. The principle of operation is straightforward and applicable to the monitoring of small lateral translations and/or rotations between different parts in machinery, buildings, bridges, ships, and other large structures.

The infrared sources and detectors are mounted on two parts of the structure, between which relative deformations are to be measured. In the x-ray telescope, each infrared source is mounted on the baseplate that holds the glancing-incidence x-ray mirrors, while its associated detector is mounted on a shelf that holds the x-ray detector. The distance along the axis of the telescope from the infrared sources and the glancing-incidence x-ray mirrors to the infrared and x-ray detectors is about 3.56 m.

Each infrared source (see figure) includes a light-emitting diode (LED) with a nominal emission wavelength of 820 nm, which nearly matches the wavelength of peak sensitivity of its associated detector. Radiation from the LED enters along the optical axis of the source through a hole in a paraboloidal reflector. After reflection from a flat central aluminized patch on an otherwise infrared-transparent window, the radiation is gathered by the paraboloidal reflector, transmitted through the transparent annulus of the window, and focused on the detector at the far end of the optical path. The housing of the source is made of titanium, which was chosen because its coefficient of thermal expansion matches that of the paraboloidal reflector. This reduces thermal stresses, thereby helping to preserve alignment over the required temperature range of 0 to 40 °C.



The **Source and Detector,** each mounted on a different part of the structure, measure rotations between, or lateral deflections of, those parts.

The dual-axis position-sensing photodiode in each infrared detector is mounted in an aluminum housing. To reduce the component of detector noise due to ambient light, the photodiode, which has a spectral response from 350 to 1,040 nm, is shielded by a narrow-band-pass filter that transmits at 820 nm with a half bandwidth of 80 nm and blocks the rest. The output of the detector consists of a difference voltage and a sum voltage for each axis. The ratio of the difference voltage to the sum voltage for each axis indicates the position of the centroid of the radiation falling on the detector. This position gives a measure of the relative rotation and/or lateral translation between the source and detector.

The source/detector pairs were calibrated for the expected range of temperatures. The addition of various errors resulted in a total three-standard-deviation error of 102 μm rms on either axis in the detector plane. At the 3.56-m baseline length, this represents an angular error of less than 6 arc seconds rms, which is within the maximum specified error of 15 arc seconds.

This work was done by John G. Hagopian of **Goddard Space Flight Center** *and William Northcutt of Fairchild Space Company. For further information, Circle 18 on the TSP Request Card. GSC-13271*

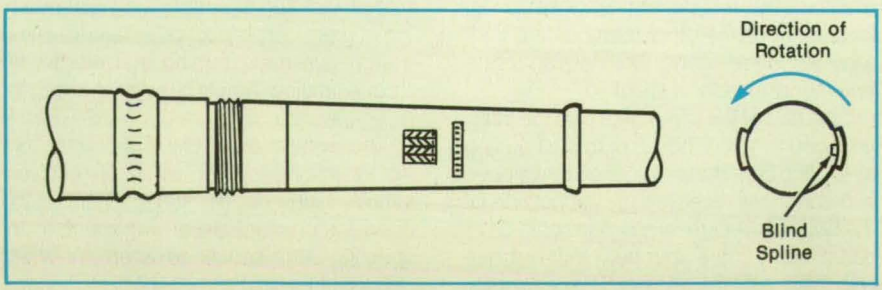
Shaft Adapter for Data Coupler

A sleeve and clamp provide for accurate measurements of stresses and strains in a shaft.

Langley Research Center, Hampton, Virginia

A shaft adapter was developed to provide a means for securing the Acurex 1200B universal data coupler to a rotating instrumented shaft: in this case, that of the tail rotor of a helicopter, The shaft adapter was needed because there were no internal or external means for securing the fiberglass transmitting collar of the data coupler and the available space was limited by the addition of strain gauges on the tapered shaft. The only other device capable of transmitting data from rotating to stationary points is a slipring. However, sliprings have the disadvantages of wear and the unreliability of electrical brush contacts.

The shaft adapter consists of two major parts: the shaft sleeve and the shaft clamp. The shaft sleeve consists of two identical halves, each of which has a window for the strain gauges (see figure). The shaft clamp



The **Shaft Sleeve Has Windows** for strain gauges mounted on the tapered rotor shaft.

also consists of two halves. The shaft clamp is keyed to the shaft sleeve to keep the sleeve from moving. The transmitting collar of the data coupler is likewise keyed to the sleeve.

Spacers and spacer washers keep the installation torque, or compression, of the collar and the sleeve from being imparted to the shaft. Rubber is also bonded to the inside of the sleeve to absorb vibration. The structural system is designed to minimize any change in the load paths where loads are transmitted from the rotor blades via the shaft to the differential gearbox housing, since a minimum change in the load path results in inaccurate readings from the strain gauges.

This system provides undistorted and accurate readings of stresses and strains in the shaft. Unlike a slipring device, it has no electrical contacts to wear out and cause problems. This system should be able to operate in a high-vibration flight environment for long times and in other situations in which it is necessary to transmit data on the stresses and strains in shafts during long times.

This work was done by James R. Elliott and Mark T. Lord of **Langley Research Center**. *For further information, Circle 159 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 18]. Refer to LAR-13805.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Experiments on Active Members in Large Space Structures

Built-in sensors and actuators monitor and control vibrations.

A report discusses continuing research on structures that include active members, which incorporate sensors, actuators, and electronic circuits to monitor and control vibrations. It describes experiments on two structures with active members as well as progress in the design, testing, and simulation of the behavior of active members. The long-term objective of this research is to develop systems to enhance the performances of large, flexible structures in space. The research may also be applicable to some terrestrial structures and testing equipment that involve close toler-

ances in the feedback control of forces and/or positions.

The active members of the test structures are equipped with various sensors and piezoelectric actuators to sense and control displacements at the micron level. Work is in progress to evaluate and adapt commercially available piezoelectric devices and to develop and test special in-house designs to optimize performance.

One of these structures is a 5-ft-long (1.5-m-long) segment of Astro-Mast, a long, narrow truss structure. Its base is cantilevered in a specially designed statically determinate interface. The six base reaction forces are supported by six struts that are flexured at each end so that they take only axial loads. The six struts are removable and can be easily replaced with active members. The active members will be used as vibration exciters to perform a system-identification test and establish a transfer-function model for the purposes of control. The Astro-Mast structure will also be used as a dynamic calibration fixture. This structure is intended to answer the following fundamental questions: How do piezoelectric active members behave as part of a structure, and can the active members be used for in situ system-identification testing?

The other test structure, called the Precision Truss, resembles truss-structure components for future astrophysics observatories in space, such as large segmented mirror telescopes and optical interferometers. This structure has been designed for maximum versatility. The six-bay, four-longeron statically indeterminate truss is approximately 6 ft (1.8-m) tall and is built up of ¼-in. (6.4-mm) aluminum tube struts connected to 1½-in. (38-mm) diameter aluminum joints. Each joint has a 26-hole pattern that can support a wide variety of truss geometries. Each strut is fitted with a custom-designed connector that allows it to be removed and replaced without disassembling the truss. In this way, active members can be easily retrofitted into any location on the structure. The base of the structure is cantilevered from a steel block weighing approximately 1,000 lb (454 kg).

Closed-loop controllers have been implemented using a high-speed digital control computer. The steady-state response of the truss to sinusoidal disturbances was reduced by 35 db, and the settling time was reduced by a factor of 30. The results of these preliminary tests suggest that control by active-members may provide unprecedented performance and adaptability.

This work was done by James L. Fanson and John A. Garba of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Experimental Studies of Active Members in Control of Large Space Structures," Circle 4 on the TSP Request Card.*
NPO-17623

Simulation of Three-Dimensional Supersonic Flows

Complicated flows can now be computed with fair accuracy.

A report describes simulations of steady, three-dimensional, viscous, supersonic flows by the NASA Ames Parabolized Navier-Stokes computer code. When executed on a suitable computer, this code can simulate flows about bodies of practical complexity — even whole aircraft.

The computer code is based on the assumption that the flow is supersonic in the streamwise direction and that the subsonic flow in the viscous sublayer is always positive in the streamwise direction. Flows with large streamwise separation and reversals of flow are excluded from treatment under these assumptions. However, crossflow separations are permitted.

Under these assumptions, the Navier-Stokes equations become parabolic in the streamwise direction, enabling a marching-solution procedure, which is computationally desirable and efficient. The boundary conditions are the usual viscous no-slip at the wall, and a characteristic procedure is used to fit the bow shock wave, which is

the outermost boundary. Because the equations are cast in conservation-law form, all discontinuities within the flow domain are predicted accurately. Because of the possible complex nature of the configuration at each axial location as one proceeds along the body, an elliptic grid generator is employed to discretize the domain of the flow.

The code has been used to simulate flows about several different solid bodies, including a blunt cone, a biconic vehicle with a spherical nose, the Space Shuttle orbiter, and a generic fighter airplane. Laminar and turbulent flows, various angles of attack, and various speeds from mach 2 to mach 14 have been considered. For the most part, the computed flows agree fairly well with measured flows. The results show that the code predicts flows in regions of canopies, wings, and canards in addition to the simple symmetric configurations ordinarily used to demonstrate computational techniques. The code also simulates interactions between aerodynamic surfaces; for example, the vortex interaction between canards and wings.

This work was done by Denny S. Chaussee of **Ames Research Center**. *Further information may be found in NASA TM-100082 [N88-21421], "High-Speed Flow Calculations Past 3-D Configurations Based on the Reynolds Averaged Navier-Stokes Equations."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12235

Computing Blood Flows

Methods developed for aerospace could be applied to the mechanics of biofluids.

A report argues for the use of advanced computational fluid dynamics to analyze flows of biofluids — especially blood. The development of supercomputers and fast flow-simulating algorithms has made computational fluid dynamics indispensible to aerospace research and design. The ability to simulate numerically and visualize complicated, time-varying three-dimensional flows can also contribute to the understanding of phenomena in the heart and blood vessels, thus offering the potential for the development of treatments for abnormal flow conditions.

The blood-flow problem is formulated via the Navier-Stokes equations for incompressible flow. Several alternative mathematical models of the viscosity tensor are presented. The transformation to generalized curvilinear coordinates that conform to the irregularly shaped and time-varying inner surfaces of blood vessels is discussed.

Methods for the solution of the Navier-Stokes equations are discussed. One method is based on the pseudocompressibility formulation, in which a small, fictitious compressibility is added to the equation of continuity to take advantage of fast, implicit numerical solution schemes that have been developed for compressible flows. Another is the fractional-step method, in which the discretized equations are advanced in time by decoupling the solution of the momentum equation from that of the continuity equation. Commonly in this method, one step is to solve for an auxiliary velocity field by use of an equation for the conservation of momentum in which the gradient of pressure is approximated by its value at the previous time step. In the next step, the pressure, which maps the auxiliary velocity onto a divergence-free velocity field, is computed. Other operator splittings can be adopted by treating the equation for momentum as a combination of convective, pressure, and viscous terms.

The next topic is the generation of computational grids. Because of branching and other complexities, in some cases flows can be divided into zones, within each of which the grid is suited to the local shape of the blood vessels. In other cases, the need for complicated interface procedures can be avoided by the use of published pro-

cedures for the generation of continuous grids.

The report presents the results of some computed bifurcated flows — simplified versions of a 90° branching off a blood vessel. As an example of the capabilities of computational fluid dynamics, the computed flow in a portion of the Space Shuttle main engine is also shown.

This work was done by D. Kwak, J. L. C. Chang, S. E. Rogers, and M. Rosenfeld of **Ames Research Center**. *Further information may be found in NASA TM-100089 [N88-21422], "Potential Applications of Computational Fluid Dynamics to Biofluid Analysis."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12253

Effects of Rapid Crushing on Composites

Effects of crushing speeds on energy-absorbing capabilities of composites are studied experimentally.

An experimental study described in a NASA technical memorandum was performed to determine whether the crash energy-absorption capabilities of graphite/epoxy and Kevlar/epoxy composite materials are functions of the speed of crushing. An additional objective was to develop an understanding of the mechanisms of crushing. Composite materials are being proposed for application to aircraft and automotive structures to meet stringent contraints on weight and the costs of manufacture. Although composites can exhibit crushing modes significantly different from those of metallic materials, recent studies have shown that composites can absorb energy efficiently.

The majority of tests on composites have been performed under quasi-static crushing conditions (that is, slow crushing) to facilitate the understanding of crushing modes and mechanisms, while little is understood about the dynamic crushing characteristics. The reported study was intended to overcome this deficiency.

In the experiments, tubes of circular cross section were used as specimens because of their inherent stability and ease of fabrication, and for comparison with previous data. The tubular specimens were crushed at speeds between 10^{-2} and 12 m/s by a closed-loop, hydraulically actuated impact system (CLOHIS). In each experiment, the speed of crushing was maintained approximately constant. The maximum crushing force in the CLOHIS was 22 kN.

The crushing force and ram speed as a function of time were recorded on a fast storage-tube oscilloscope. A hydraulic power supply provided the means to propel the ram and crushing apparatus at the required speed. The ram was accelerated to the specified speed within the first few centimeters of its travel; after that, the tube specimen was crushed between the platens. Entrapped air was allowed to escape through holes incorporated into the system to minimize any air-spring effects that could occur during the dynamic crushing of tube specimens. Approximately 2,000 data points, evenly spaced in time, were recorded per ram-speed and crushing-force data channel.

On the basis of the results of these tests, the energy-absorption capability of the composite materials was determined to be a function of the speed of crushing. The magnitude of the effects of speed of crushing on energy-absorption capability was determined to be a function of the mechanisms that control the crushing process. The modes of crushing based upon the exterior appearances of the crushed tubes were unchanged for the composite materials. This technology could be applied to the enhancement of safety and crashworthiness of automobiles, the design of energy-absorbing devices in machinery, and problems that involve explosions and im-

pacts.

This work was done by Gary L. Farley of the U.S. Army Aerostructures Directorate at **Langley Research Center**. *Further information may be found in NASA TM-89122 [N87-25438], "The Effects of Crushing Speed on the Energy-Absorbing Capability of Composite Material."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LAR-14087

Comparison of Calculations of Viscous Transonic Flow

Results of a variety of numerical simulations are compiled in a report for easy comparison.

A report presents a compendium of results of numerical simulations of viscous transonic flows about airfoils. The results, which were reported at the 1987 Viscous Transonic Airfoil Workshop, appear in the report in narrative, tabular, and graphical form to facilitate comparisons with each other and with measured data.

Fifteen working groups are represented by 23 sets of numerical results. These airfoils were used in this study and are given by:

- The classical NACA 0012 airfoil,
- The RAE 2822 supercritical airfoil, and
- The recently-developed Jones airfoil.

The test cases range from attached subcritical flows to transonic flows with separations induced by both shocks and angles of attack. The working groups used methods ranging from momentum-integral boundary-layer techniques coupled with transonic potential inviscid codes to full Navier-Stokes techniques.

The report concludes that, for calculations of attached flows about airfoils, numerical methods have reached a high level of development. Most methods can predict lift to an accuracy within ±3 percent and drag to within ±5 percent. Other computed flow-field data — such as velocity boundary-layer profiles and skin-friction distributions — are in good agreement with each other and with experiments.

However, for calculations of separated flows about airfoils, numerical methods are not developed as well. This is largely because the mathematical modeling of turbulence in regions of separated flow is not accurate. Recent progress suggests hope for the future, nevertheless.

The report notes that many errors in computer programs are solely numerical in nature. Comparisons of solutions with each other are valuable because they enable the identification of such errors. The most important numerical errors are caused by inappropriate clustering and refinement of computational grids. Further studies of the refinement of grids could help to eliminate these errors.

This work was done by Terry L. Holst of **Ames Research Center**. *To obtain a copy of the report, "Viscous Transonic Airfoil Workshop Compendium of Results," Circle 3 on the TSP Request Card.*
ARC-12192

Machinery

Hardware, Techniques, and Processes

Computer Programs

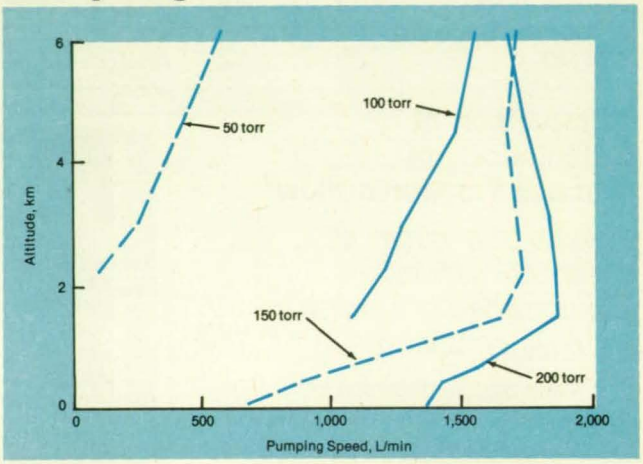
Venturi Air-Jet Vacuum Ejector for Sampling Air

Fast response in measurement of CO is achieved.

Langley Research Center, Hampton, Virginia

The NASA Global Tropospheric Experiment program includes many trace-gas-sensing experiments that require sampling of ambient air by use of aircraft. These experiments require some form of air-flow system, which generally includes mechanical vacuum pumps. The vacuum pump is the principal component of instrumentation needed to achieve the fast response required for measurements of flux. Mechanical vacuum pumps collectively constitute a heavy payload, use many kilowatts of aircraft electrical power, and generate much heat that is often impossible to dissipate satisfactorily.

An alternative type of vacuum pump that has many desirable characteristics for use in aircraft is the venturi air-jet vacuum ejector. This pump is light in weight, requires no electrical power, does not contribute heat to the aircraft, and can provide high pumping speeds at moderate suctions. The high-pressure motive gas required for this type of pump can be bled from the compressor of an aircraft engine with negligible effect on the performance of the engine.



The **Performance of the Venturi Pump** meets or exceeds design specifications.

A venturi pump is now being used as a source of vacuum for the differential-

absorption CO-measurement (DACOM) instrument developed at the NASA Langley Research Center. The DACOM is being modified to achieve in situ measurements of CO at a frequency response of 10 Hz. This frequency response will provide an improvement in spatial resolution and can potentially lead to a capability to measure the turbulent flux of CO by use of the eddy-correlation technique.

To achieve such fast response in this instrument, the high rate of flow of 17-standard cubic feet per minute (8×10^{-3} standard cubic meters per second) must be achieved at a suction of 200 torr (27 kPa). The mechanical pump capable of delivering this performance weighs approximately 500 lb (227 kg) and consumes approximately 6 kW of electrical power, which is dissipated in the cabin of the aircraft. In contrast, the venturi pump specifically designed for DACOM weighs approximately 20 lb (9.1 kg), consumes no electrical power, and does not heat the cabin.

This venturi pump was recently installed on the Electra aircraft that is based at the NASA Wallops Flight Facility and that has successfully completed a series of test flights. The pump was rigidly mounted on the fire wall within the compartment of engine 3 and connected to the DACOM instrument via a 15-ft. (4.6-m) vacuum line. The pump was designed to use motive gas [475 °F (246 °C), 80 psi (0.55 MPa), 64 standard cubic feet per minute (3.0×10^{-2} standard cubic meters per second)] from the 14th stage of the compressor 3 to achieve the required flow and suction.

During the flight tests, the pressure and temperature of the motive gas as well as the pressure and rate of the suction flow were monitored. The pumping speed of the venturi pump was determined as a function of altitude from sea level to 20,000 ft (6.1 km), pressure of the motive gas from 55 to 95 psi (0.38 to 0.66 MPa), speed of the aircraft from 180 to 250 kn (93 to 129 m/s), and suction from 50 to 300 torr (7 to 40 kPa) (see figure). The performance of the venturi pump met or exceeded the design specifications. Venturi pumps with higher pumping capacities are also available and can be installed without significant impact upon the supply of motive gas.

This work was done by Gerald F. Hill, Glen W. Sachse, and L. Garland Burney of **Langley Research Center** *and Larry O. Wade of Planning Research Corporation. For further information, Circle 54 on the TSP Request Card. LAR-14024*

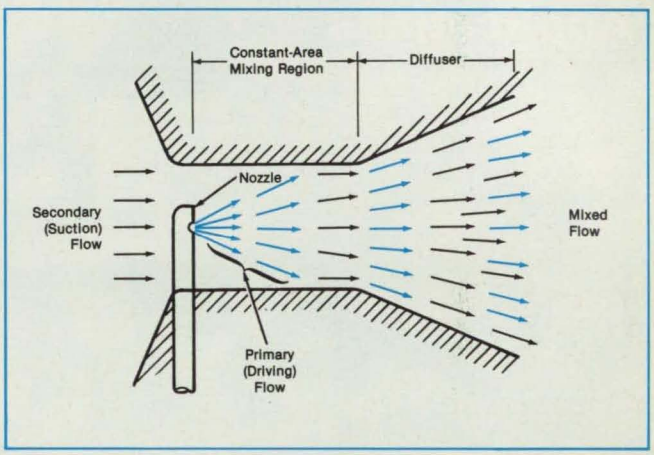
Control-Volume Analysis of Thrust-Augmenting Ejectors

A new method of analysis applies to transient flows.

Lewis Research Center, Cleveland, Ohio

A method of analysis of transient flow in a thrust-augmenting ejector is based on a control-volume formulation of the governing equations. Thrust-augmenting ejectors are being considered as potential elements of propulsion subsystems of short-takeoff/vertical-landing airplanes.

A thrust-augmenting ejector is often described as a fluidic pump that employs the momentum of a fast jet (the drive or primary flow) from a primary nozzle to entrain and pressurize a suction stream (the secondary flow). A typical thrust-augmenting ejector consists of a high-pressure nozzle to accelerate the primary flow, an inlet section to accelerate the secondary flow, an intermediate section in which the primary and secondary flows exchange momentum, and a diffuser to match the pressure of the discharge with that of the atmosphere (see figure).



In a **Thrust-Augmenting Ejector** a fast jet (the primary flow) entrains a slower secondary flow.

The further exploration of ejector concepts imposes the following three requirements on the numerical simulation of the performance of an ejector:

1. The mathematical model must be predictive, not parametric.
2. The turbulent flow in the mixing region of the ejector must be appoximated.
3. The final system of equations must be amenable to simulation in real time.

The new method of analysis was developed to meet these requirements.

The control-volume formulation of the governing equations yields time derivatives of the field-variable volume integrals that express the conservation of energy, mass, momentum, and entropy. Because these volume integrals cannot be converted into surface integrals, the spatial distributions of the field variables must be approximated. Under the assumption that the physics of the mixing region dominate the characteristics of the performance of the ejector, the spatial subdivision of the mixing region enables the approximation of the conditions in each subvolume by characteristic profiles of velocity, pressure, and temperature.

Extending downstream along the centerline from the inlet plane of the mixing region, there is a potential-core region characterized by fairly uniform axial velocity, with no radial velocity. Surrounding the potential core is the region of mixed flow where the centerline velocity decays with increasing radius, due to transport of momentum to the entrained secondary flow. The potential-core region is represented by an analytical model calibrated by experimental data. The turbulent flow is represented by self-similar profiles of turbulent-flow-field variables. Time derivatives of the volume integrals are reduced to time derivatives of the characteristics of the field variables. Then treating the surface integrals in the usual way, one obtains a set of differential equations in time.

Inasmuch as the focus is upon the calculation of thrust generated by the ejector, fewer than 10 subdivisions of the mixing region are needed. Although the resulting description of the flow in the mixing region is terse and the turbulent interaction between the primary and secondary flows is crude, the final equations have the potential to predict thrust in real time, meeting the requirements.

This work was done by Colin K. Drummond of Sverdrup Technology, Inc., for **Lewis Research Center**. *Further information may be found in NASA CR-182203 [N89-12566], "A Control-Volume Method for Analysis of Unsteady Thrust Augmenting Ejector Flows."*

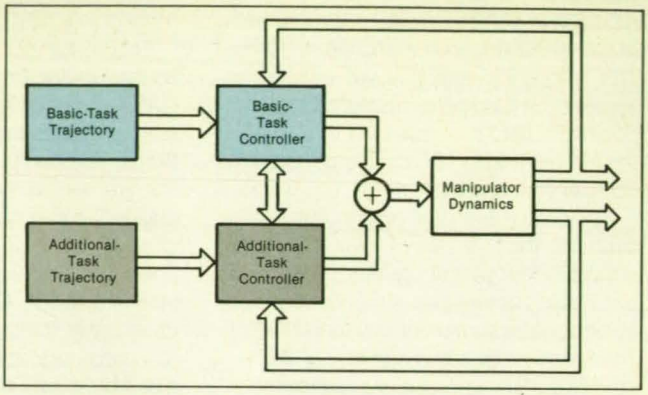
Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-14877

Increasing the Dexterity of Redundant Robots

Redundant coordinates are used to define additional tasks.

NASA's Jet Propulsion Laboratory, Pasadena, California

Configuration control is emerging as an effective way to control the motions of a robot that has more degrees of freedom than are necessary to define the trajectory of the end effector and/or of the object to be manipulated. The extra or redundant degrees of freedom can be used to give the robot humanlike dexterity and versatility.



In configuration control, the configuration of the robot is represented mathematically by a set of configuration variables, which is a generalized coordinate vector that is more relevant to the overall task than is the vector of joint coordinates that appears in conventional approaches to control. The generalized coordinate vector consists of the coordinates of the end effector in task space, plus a number of kinematic functions that involve the redundant degrees of freedom. The basic task of the control system is to make the coordinates of the end effector follow the desired trajectory. The kinematic functions can be selected to define an additional task — for example, the avoidance of obstacles or kinematic optimization to enhance manipulability. In effect, the additional task defines the trajectory in the redundant degrees of freedom (see figure).

The configuration variables can be used in an adaptive control scheme, which does not require knowledge of the complicated mathematical model of the dynamics of the robot or the parameters of the object to be manipulated. The configuration-control method can be implemented in either a centralized or a decentralized control system. Because configuration control is computationally very fast, it is suitable for the development of algorithms for the real-time control of robots.

The **Configuration Controller** acts, in effect, as a basic-task controller (which makes the end effector move along the desired trajectory) plus an additional-task controller (which performs an additional task—for example, kinematic optimization).

This work was done by Homayoun Seraji of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 123 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17801.

Fabrication Technology

Hardware, Techniques, and Processes

Arc Reflector for Welding Ducts

The reflector is improved for use on round ducts.

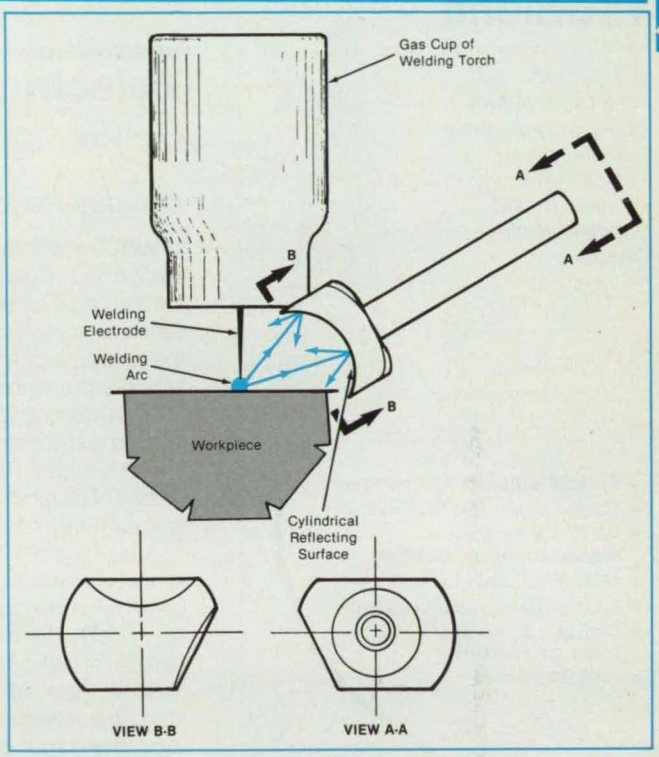
Marshall Space Flight Center, Alabama

An arc-light reflector for a through-the-torch welding vision system is designed expressly for use in welding ducts of small diameter. The reflector has a cylindrical surface instead of the conical surface used for flat-plate welds.

The reflector directs light from the welding arc to the workpiece so that it presents a bright image for the vision system, by means of which the weld is viewed along the axis of the welding torch. The image could be used, for example, to control a welding robot. The cylindrical contour of the reflector distributes the light more evenly over the viewed surface than a conical reflector would.

The reflecting surface is blasted with aluminum oxide to obtain diffuse reflection. The position and orientation of the reflector can be adjusted by a small two-axis manipulator.

The reflector is no wider than the gas cup on the welding torch. The reflector is not attached to the cup, which, therefore, can be removed and replaced with ease.



The **Cylindrical Reflector** is positioned to reflect light diffusely from the welding arc onto the nearby surface of the workpiece for most advantageous viewing along the axis of the welding torch.

This work was done by Jeffrey L. Gilbert of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29640

Compact Pinch Welder

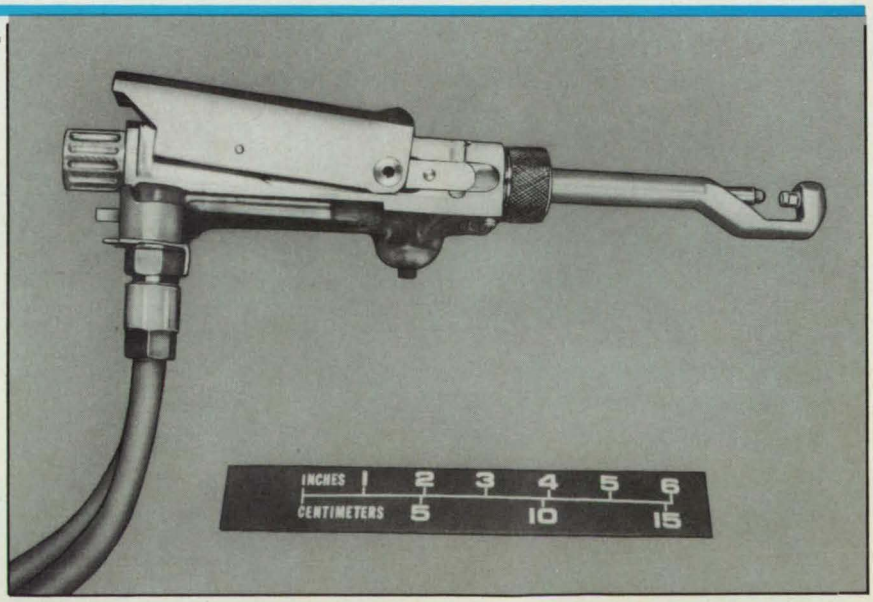
An easy-to-use gun boosts productivity.

Marshall Space Flight Center, Alabama

A compact resistance-welding pinch gun lets one operator do jobs that formerly needed two workers. The gun is light in weight and produces repeatable, high-quality weld joints.

The gun has a pair of electrodes that pinch the workpiece between them when the operator presses a lever (see figure). One operator can position the electrodes in precisely opposing positions; it is not necessary to have an operator for each electrode. Pressure from the preset spring loaded plunger provides the welding force.

When the electrodes are in welding po-



The **Welding-Electrode Head** (right) rotates for easy positioning. The lever at top of the handle activates a spring to pinch the electrodes together at a preset welding force. The button at the bottom of the handle activates the welding current. Cables at left supply electrical power.

sition and the welding force is applied, the operator pushes a button on the handle of the gun to turn on the welding current. A spot weld is quickly made, and the operator can move to the next weld position.

The gun has a rotating electrode head with narrow jaws that makes it easy for the operator to reach into limited-access areas and maneuver the gun. It can be used for alternating-current or direct-current welding.

This work was done by Thomas F. Starck and Andrew D. Brennan of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18]. Refer to MFS-29612.

Dielectric Coating for Hot-Film Flow Sensors

A polymer/silica combination withstands cryogenic cycling.

Langley Research Center, Hampton, Virginia

With the very thin boundary layers and cryogenic temperatures encountered in the National Transonic Facility (NTF), conventional sensors are not acceptable for the detection of transitions in flows. Typically, hot-film sensors used to detect transitions are deposited on substrate materials, and the substrates are attached to airfoils. The substrates contribute to the roughnesses of surfaces and can cause boundary-layer transitions.

A very-thin-film dielectric coating that is stable over a range of temperatures has been developed to satisfy several criteria for the NTF. This dielectric coating, a combination of fused silica and a thermoplastic polymer, has sufficient stability to withstand the stresses placed upon it by cycling to and from cryogenic temperatures. The coating can be tailored to meet almost any criterion of roughness height.

First, the airfoil is coated (see figure) with a vapor-deposited thermoplastic polymer to a thickness of approximately 3 to 6 μm. Next, a layer of fused silica (SiO_2) is vapor-deposited to a thickness of 7.5 kÅ by electron-beam evaporation with simultaneous bombardment by a beam of ions. Then metal layers used for sensors are electron-beam-evaporated directly onto the dielectric coating.

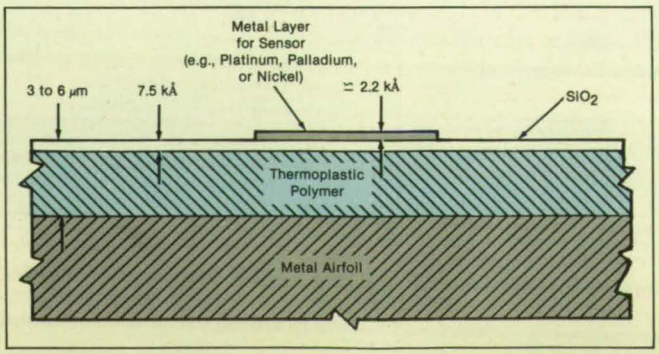
The commercial thermoplastic polymer used was chosen because of its excellent electrical and mechanical properties and the fact that it can be deposited from a vapor uniformly over large areas without the formation of pinholes. It has a high percentage of elongation to break that accommodates the different linear coefficients of expansion of the three major components: the stainless-steel airfoil, the polymer, and the fused silica. Because of its flexibility, the polymer is not an acceptable substrate for such vapor-deposited metals as platinum, palladium, and nickel, commonly used for hot-film sensors. These metals, when vapor-deposited, have intrinsic stresses in the films, and the polymer surfaces yield to the film stresses at the interfaces with the metals, causing fractures in the films.

SiO_2 was chosen because it is a very thermally and chemically stable oxide and is easily vapor-deposited. Therefore, the SiO_2 layer is incorporated as a buffer between the polymer and metal films.

Hot-film devices have been fabricated on this thin-film dielectric layer and tested with good results. This technique should prove potentially useful for research in the application of hot-film sensors to airfoils.

This work was done by Purnell Hopson, Jr., and Sang Q. Tran of **Langley Research Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 18]. Refer to LAR-13678.



Both the Polymer and the Fused Silica are vapor-deposited directly onto the metal airfoil.

Angle-Ply Weaving

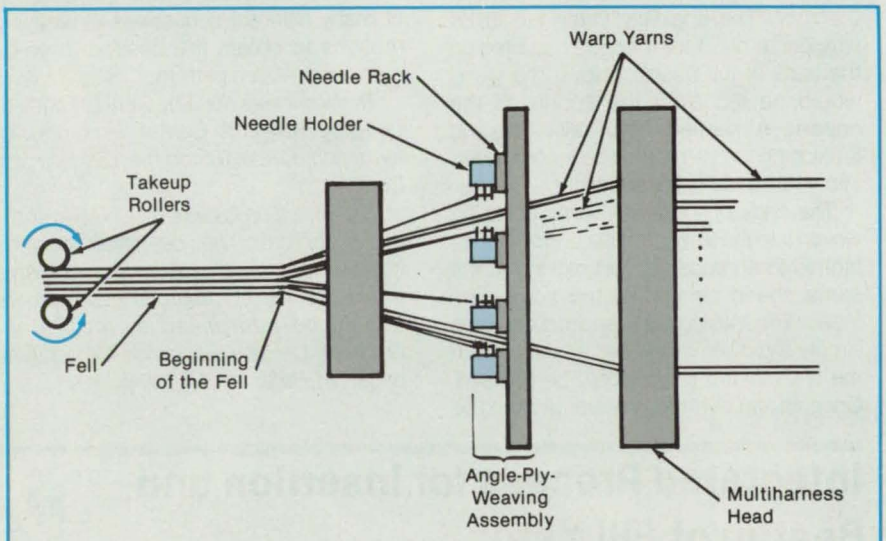
Fibers can be woven along the bias.

Langley Research Center, Hampton, Virginia

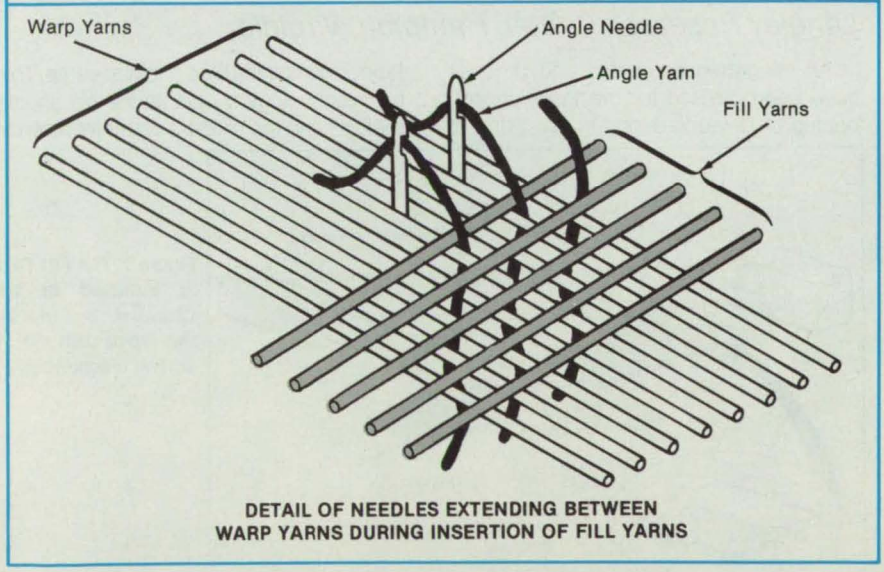
Bias-direction or angle-ply weaving is a proposed new process for weaving fibers along the bias in a conventional planar fabric or in a complicated three-dimensional multilayer fabric preform of a fiber-reinforced composite structure. Fibers woven along the bias would increase the shear stiffness and shear strength of the preform, increasing the value of the preform as a structural member.

In conventional weaving, warp (lengthwise) yarns are alternately raised and lowered (a motion called "forming the shed"), and fill (weft or widthwise) yarns are inserted in the shed and beaten into the fell (the apex of the shed). Angle-ply weaving (see Figure 1) is based upon the movement of racks of needles and the corresponding angle yarns across the fabric as the fabric is being formed. The needles could be extended periodically to form a shed, analogously to the raising and lowering of the warp yarns in conventional weaving. The angle of the angle plies would be controlled via the speed of the motion of the needles across the fabric relative to the speed of advance of the fabric. Depending upon the layer-interconnection design, the angle-ply needles could be extended through the adjacent layer(s), and fill yarns inserted.

The needle-rack assembly (see Figure 2) would include needles (the angle-ply needles) in a holder moved along the rack. The needles could be extended pneumati-



BIAS-DIRECTION WEAVING ASSEMBLY IN CONVENTIONAL MULTIHARNESS LOOM (INSERTION OF FILL YARNS NOT SHOWN)



DETAIL OF NEEDLES EXTENDING BETWEEN WARP YARNS DURING INSERTION OF FILL YARNS

Figure 1. **Angle-Ply or Bias-Direction Weaving** could be incorporated into a conventional multiharness loom for making planar fabric with a bias weave.

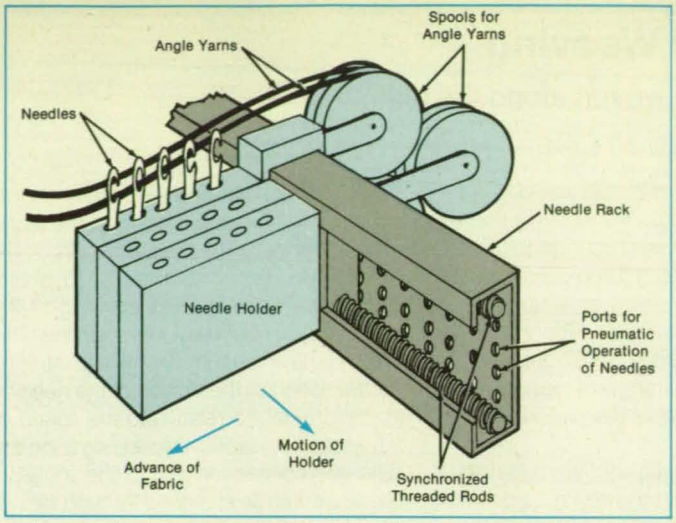


Figure 2. The **Needle-Rack Assembly** would feed the angle yarns to the fabric being formed. The needles in the holder would move along the rack (across the path of the advancing fabric).

cally or electromagnetically. After the holder and its needles had moved to the end of the rack, the needle-and-holder assembly would be removed, and new angle-ply yarns would be inserted into the needles and remounted at the beginning of the rack. The angle-ply yarns would be wrapped around small spools mounted on the back of the needle holder. The yarns would be fed from the spools to the needles. A mechanism for rewinding and tensioning the yarn would be incorporated into each spool subassembly.

The ends of the angle yarns could be woven into the selvage of the preform or attached to an edge support moving at the same speed as that of the advancing fabric. The moving edge support could be simply a moving sticky belt against which the ends of the yarns would be pressed. Once an angle yarn was woven, it would be released (pulled) from the belt.

The various weaving mechanisms would be actuated by stepping motors and other electromechanical devices. The use of state-of-the art microcomputers to control these devices would enable the selection of many different sequences of weaving motions to obtain the desired three-dimensional woven pattern.

This work was done by Gary L. Farley of **Langley Research Center**. *For further information, Circle 165 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 18]. Refer to LAR-14048.

Integrated Process for Insertion and Beatup of Fill Yarns

This process works with angle-ply weaves.

Langley Research Center, Hampton, Virginia

An integrated apparatus and process have been devised for the insertion and beatup of fill yarns during the weaving of fabrics containing bias-oriented yarns. This new technology supplants the old shuttle method and the modern water-jet method

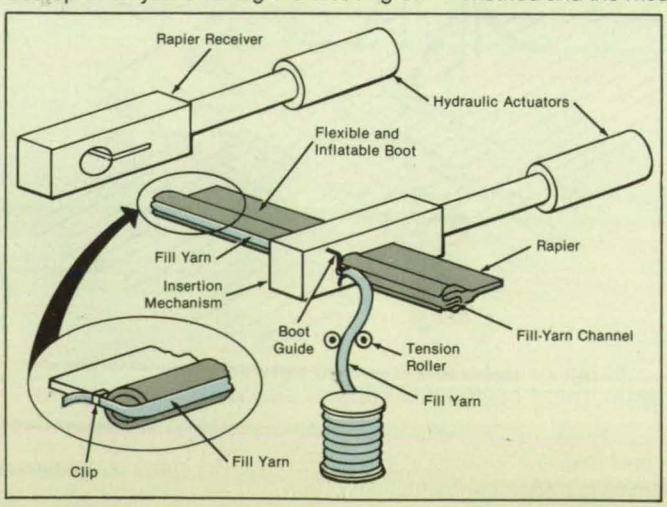


Figure 1. The **Fill Yarn Is Inserted in the Channel** by moving the rapier past the insertion mechanism.

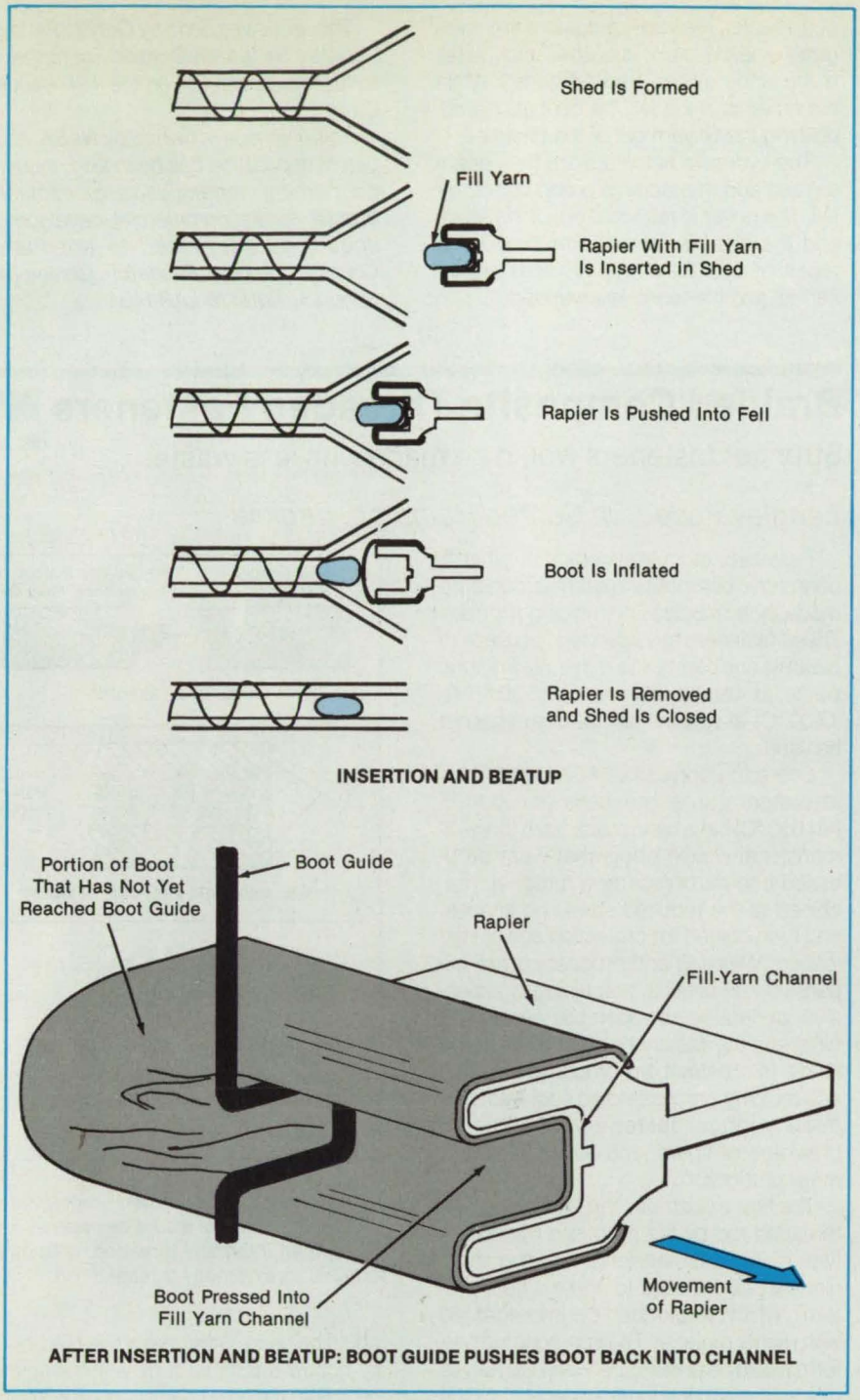


Figure 2. The **Fill Yarn Is Inserted and Beat Up** in this sequence of steps. After insertion and beatup, the rapier is moved past the insertion mechanism in the opposite direction, and the boot guide pushes the boot back into the fill-yarn channel.

of insertion and the conventional reed method of beatup. The integrated apparatus and process are intended for use in the angle-ply or bias-direction weaving process described in the preceding article because the methods for inclusion of the bias-oriented yarns typically result in sheds that are incompatible with conventional reed beat-up techniques.

The major components of the apparatus are the rapier, the fill-yarn channel, the flexible and inflatable boot that fits in the fill-yarn channel, the boot guides, and the hydraulic actuators that push the rapier into the fell of the fabric (see Figure 1). A clip holds one end of the fill yarn at one end of the rapier while the fill yarn is inserted in the channel. The fill yarn is inserted under tension to keep it straight. The flexible boot is guided back into the channel by use of a guide when the rapier is extended and retracted. The insertion of the fill yarn also assists in the reinsertion of the boot into the channel.

As the rapier is extended across the fabric, the fill yarn is inserted in the channel. When the rapier is fully extended, the rapier receiver catches and holds the end

of the rapier. Hydraulic actuators are energized, and the rapier is pushed into the fell of the fabric, as depicted in Figure 2. While the rapier is in the fell, the boot is inflated, pushing the fill yarn out of the channel.

The hydraulic actuators are then deenergized and the rapier is pulled out of the fell. The rapier is retracted out of the shed, and the shed is closed. This process is repeated until all of the fill yarns are inserted, and the fabric is advanced.

This work was done by Gary L. Farley of **Langley Research Center**. *For further information, Circle 164 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 18]. Refer to LAR-14046.

Braided Composite Threaded Fasteners

Stronger fasteners would be made with less waste.

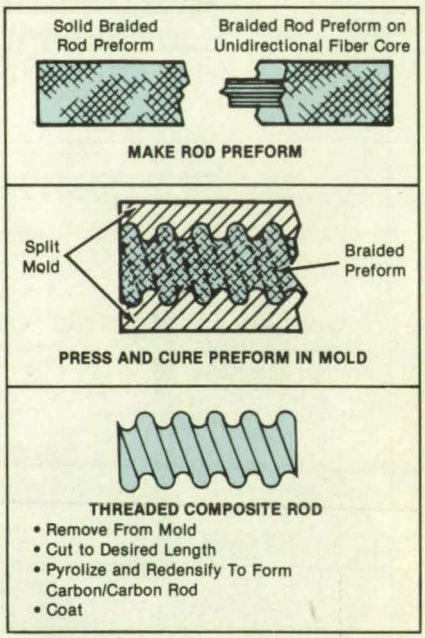
Langley Research Center, Hampton, Virginia

Fasteners of carbon/carbon or other fiber/matrix composite materials could be made by a braiding-and-molding process. These fasteners are intended for use with ceramic and composite-material structural parts at temperatures $\gtrsim$ 2,500 °F ($\gtrsim$ 1,400 °C), at which metal fasteners cannot be used.

Coated carbon/carbon fasteners for use at temperatures in excess of 3,000 °F (~1,600 °C) have been made from three-dimensional woven billets that were processed into carbon/carbon material, machined to the required sizes and shapes, and then coated for protection against oxidation. Weaving and processing are expensive and difficult. Machining is expensive, generates considerable waste, and weakens the fasteners by damaging the fibers. In constrast, the proposed braiding-and-molding process would cost less, produce stronger fasteners by avoiding breakage of fibers, and be adaptable to mass production.

The figure illustrates the fabrication of a threaded rod by the proposed method. A two- or three-dimensional braiding technique would be used to make a fiber preform, which would then be impregnated with matrix material. The impregnated preform would be pressed between the halves of a split mold, the inner surface of which would have the desired thread pattern. After curing under pressure, the threaded rod would be removed from the mold, cut to desired lengths, processed to final state, and coated for protection against oxidation at high temperatures.

Many variations of the basic concept are possiible. The braiding could be performed with fibers precoated with matrix material, eliminating the impregnation step. The preform could be made by braiding onto a previously formed unidirectional fiber core, which would provide increased tensile stiffness and strength. Plugs could be inserted in preforms and later removed to form screwdriver slots, sockets, keyways, and the like. Other core materials could be used. Other parts like nuts, hubs, or hollow shafts with or without splines could be made by use of various combinations of internal and split external molds. Even in cases in which threads could not be completely molded onto braided preforms, it is expected that threads superior to those machined onto woven billets could be machined onto the braided preforms, and at a lower cost.



A **Preform of Braided Fibers** impregnated with matrix material would be pressed and cured in an internally threaded, split mold to make an externally threaded rod.

This work was done by James Wayne Sawyer of **Langley Research Center**. *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 18]. Refer to LAR-14062.

Enhancement of Penetrant-Inspection Images

Software makes flaws more apparent and creates a data base.

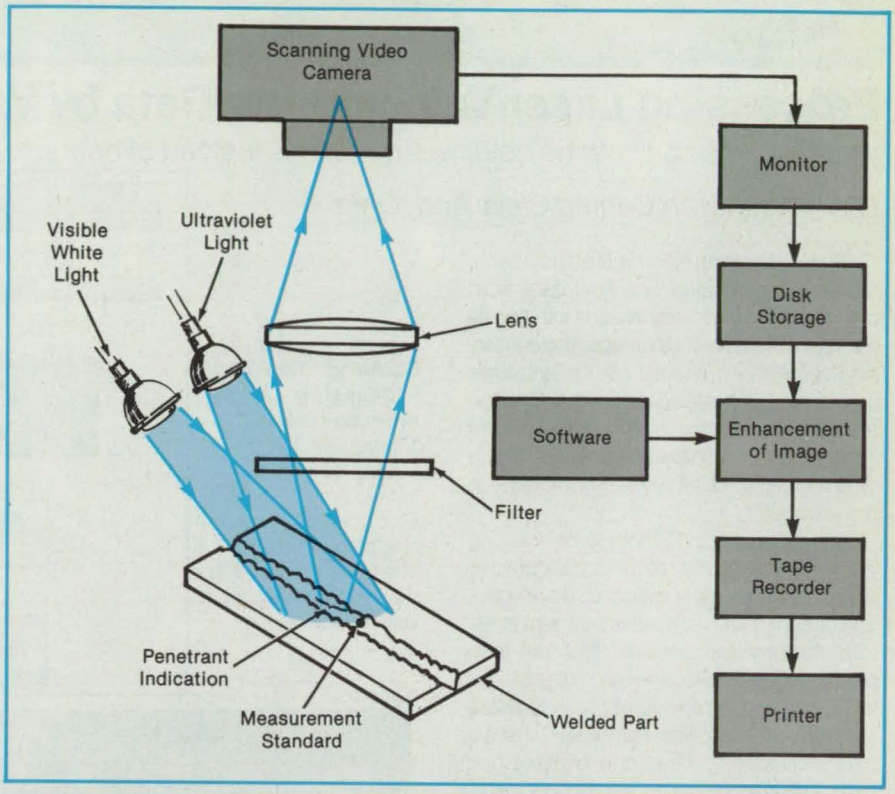
Marshall Space Flight Center, Alabama

A proposed computerized video system would process images of fluorescent dyes absorbed in flaws in welds. The system would enhance images of cracks and voids so that they can be evaluated by human inspectors without the subjectivity that affects ordinary inspections. The system would also provide quantitative measurements that could be compiled in a data base for future use.

The system (see figure) would freeze images on the video screen so that they could be stored, magnified, and documented by photographs. It could remove unwanted background images and would exaggerate the differences between light and dark areas. It could convert positive images to negative ones to make flaws more obvious.

The system would be able to delineate "windows" — sections of the image that could be enhanced, magnified, or stored. It could change the shape, size, and position of a window as directed by the operator. It could "cut and paste" — that is, isolate sections of images and reposition them side-by-side for comparison.

It could sharpen the edges of fine features of an image. With its picture elements calibrated to a standard, the system could measure the sizes of flaws. It could identify flaws by type by comparing them with data on flaws stored in memory. It could discern true flaws from harmless features, thereby eliminating unnecessary rework.



A **Video Camera**, held by an operator or by a remote manipulator, would view a weld illuminated by visible white and ultraviolet light. Images of penetrating dye in cracks and voids in the weld joint would appear on a video monitor. The fluorescent features would also be enhanced by software to facilitate the identification of true flaws and record important data.

This work was done by Rhonda C. Wilson of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 5 on the TSP Request Card.*
MFS-29496

Ultrasonic Abrasive Removal of EDM Recast

A form-fitted tool is vibrated in the presence of abrasive material.

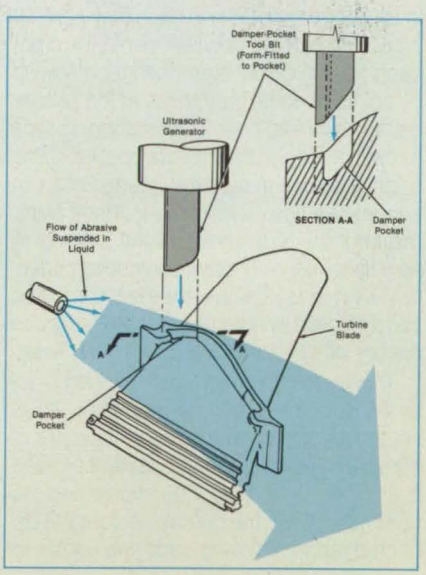
Marshall Space Flight Center, Alabama

An ultrasonic abrasive process removes the layer of recast material that is generated during the electrical-discharge machining (EDM) of a damper pocket on a turbine blade. Heretofore, recast material has been removed by blasting with abrasive powder.

The removal of material is controlled precisely by a tool bit that is form-fitted to the damper pocket. Abrasive medium is made to flow across the turbine blade while the tool is vibrated ultrasonically in the damper pocket (see figure). The vibrations of the tool bit direct the abrasive material to the only areas from which it is desired to remove material — the walls of the damper pocket.

The amount of material removed can be controlled precisely. This amount is determined mainly by the duration of the ultrasound. Material is removed to an equal depth on all surfaces in proximity to the tool bit.

This work was done by Johnny L. Mandel and Marlowe S. Jacobson of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29545



The **Form-fitted Tool** is vibrated ultrasonically in the damper pocket from which material is to be removed. The vibrations activate the abrasive in the pocket.

Processing Laser-Velocimetric Data by Vector Scanning

Velocity plots can now be obtained in minutes instead of hours.

Lewis Research Center, Cleveland, Ohio

Vector scanning (see Figure 1) is a technique for processing flow-field data from pulsed-laser-velocimetry images into two-dimensional velocity-vector maps. Vector scanning requires no special equipment other than a charge-coupled-device (CCD) camera, circuitry to digitize the output of the camera, and a computer. Once the image data are digitized, all processing is done in the computer.

The conventional technique for reducing laser-velocimetric data requires photographic plates to be multiply exposed, developed, and scanned with special equipment to extract the raw image data, which are then processed into velocity-vector maps. This technique requires several hours to make each velocity map, whereas the vector-scanning technique requires only minutes and can sometimes be performed during a measurement.

To perform a vector-scanning measurement, a flow field is seeded with micronized particles of aluminum oxide, and the plane in which velocities are to be measured is illuminated with a sheet of light from a continuous-wave laser. The CCD camera records a sequence of five successive images of the illuminated particles in the flow field. The minimum time between images is one-sixtieth of a second. The raw, digitized-image data from the camera are preprocessed to determine the centroid of the image of each particle in each flow-field image. The particle-position centroids from each flow-field image are then represented by points of equal brightness at the picture elements (pixels) nearest the centroids, thus forming a map of the particle positions. The brightness of the centroid images of each successive flow-field image is made twice the brightness of those of the preceding flow-field image. The five brightness-coded, flow-field image maps are then combined into a single map that shows the time/space history of each particle in the flow field.

The vector-scanning algorithm then processes the five-exposure-map data by a searching operation that is reminiscent of convolution except that it is faster because it involves only logic operations and no arithmetic. First, the operator enters the expected range of flow speeds and angles to be searched. For each flow speed and angle, a particle that moves at the corresponding velocity is identified in the image as a line sequence of five intensity-coded picture elements. The computer assigns that velocity to each such sequence. The points that have not been assigned to particle/velocity sequences are scanned again for conformity or nonconformity to patterns representing other velocities. This process is repeated automatically until all of the coded-intensity centroid images are either assigned to particle/velocity sequences, found to be parts of incomplete sequences, or otherwise accounted for.

Figure 2 (a) shows the image of the pulse-illuminated particles suspended in a heated-fluid experiment recorded by a 512×488 picture elements CCD. Five successive frames like this one were recorded at intervals of 660 ms. All computations were performed in FORTRAN 77 on a 25-MHz personal computer containing an 80386 microprocessor. It took only 350 seconds to process the raw image data into the velocity-vector map shown in Figure 2(b). More recent work indicates data processing time can be reduced by two orders of magnitude. No array processors or specialized hardware are required for implementing the vector-scanning technique.

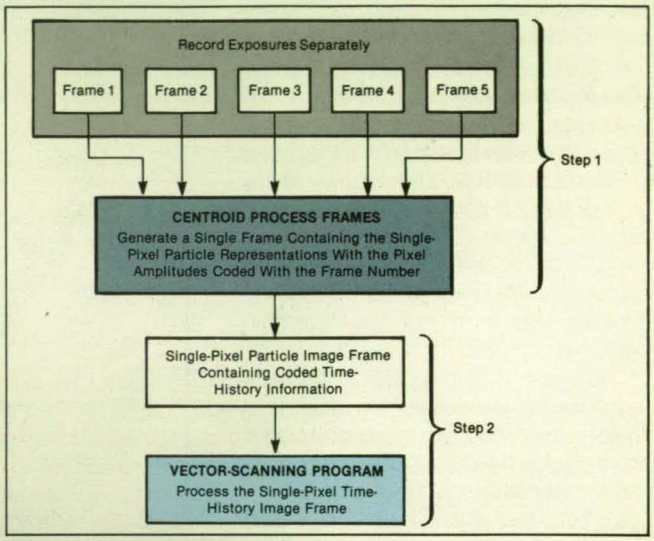
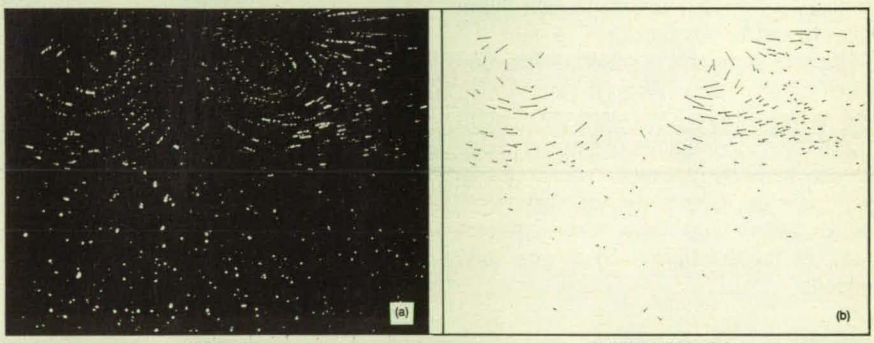


Figure 1. **Vector-Scanning Two-Step Processing Algorithm**, processing step 1 produces the time-history coded image frame ready for analysis by the vector-scanning program in step 2. The output of step 2 is the two-dimensional velocity-vector map.

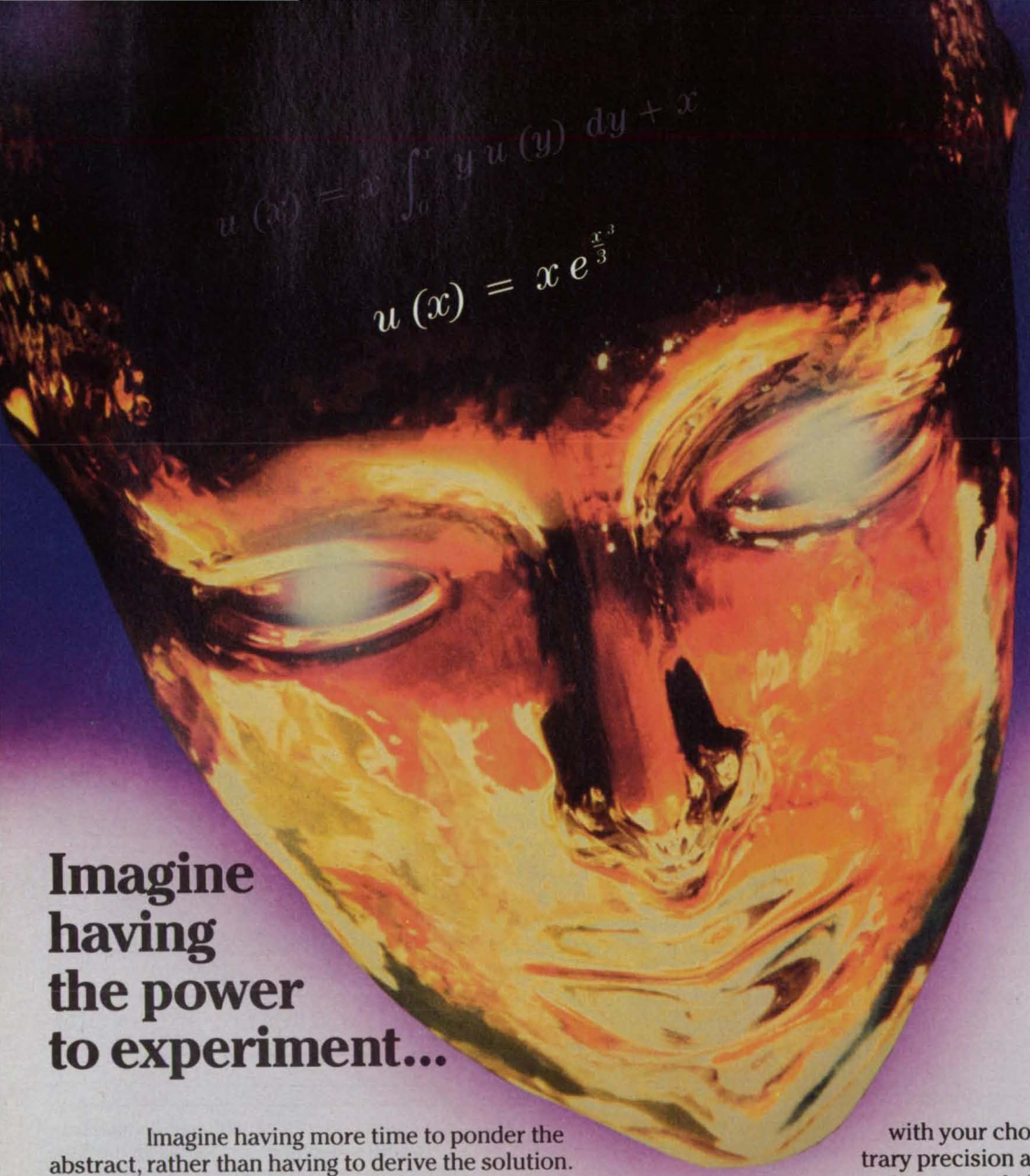


CCD IMAGE VELOCITY-VECTOR MAP

Figure 2. **Particles In a Circulation Fluid** are illuminated by a pulse of laser light (a). A sequence of images like this one is processed to obtain the velocity-vector map shown in (b).

This work was done by Mark P. Wernet of **Lewis Research Center**. *For further information, Circle 91 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center [see page 18]. Refer to LEW-14925.



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Circle Reader Action No. 524

Concurrent Finite-Element Analysis on Hypercube Computers

A robust general approach requires minimal tailoring to specific cases.

NASA's Jet Propulsion Laboratory, Pasadena, California

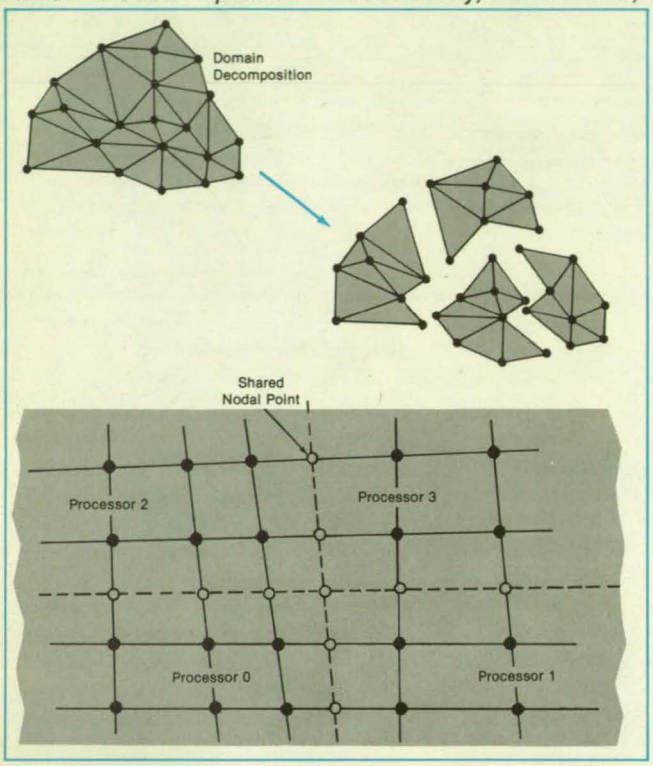


Figure 1. The **Computational Domain** is decomposed into subdomains, each assigned to one processor. Some nodal points fall on boundaries between subdomains and are shared by the adjacent processors.

An improved approach to the execution of finite-element codes on hypercube and similar concurrent data processors increases the efficiency of computation for many different types of problems. The approach is based on a flexible general model of computation on, and communication among, large-node parallel processors.

Merely mapping a serial finite-element-method code onto a system of parallel processors is a straightforward undertaking in which the computational domain is decomposed into subdomains or nodes that contain contiguous finite elements, each subdomain being assigned to one of the processors (see Figure 1). In the general model, the information relevant to the degrees of freedom or matrix elements of a node resides in the local memory of the proccessor assigned to the given subdomain. A given processor has direct access only to its "own" information and can be thought of as solving a smaller version of the original full problem, subject to some special boundary conditions. The various processors communicate with each other to exchange the boundary information and obtain a global solution. The problem is to devise a mapping that increases the speed of computation by decreasing the amount of necessary communication among processors.

One conventional approach to the solution of the domain-decomposed problem involves direct methods (e.g., variants of Gaussian elimination), which are robust but can be too expensive for systems of large rank and bandwidth, such as arise from large three-dimensional domains. Another conventional approach involves iterative methods [e.g., the preconditioned-conjugate-gradient (PCG) method], which require less communication than direct methods do but are not robust, in the sense that their convergence properties are highly problem-dependent and difficult to guarantee.

The new approach is a hybrid that combines direct methods within the subdomains and PCG iteration on the remaining boundary system to obtain a method of solution that is both robust and efficient. In the iterative component of the method, the rank of the system is a small fraction of the rank of the full unreduced system; this feature enhances the convergence of the PCG iteration. In the direct component of the method, the cost is only that of the reduction of small subdomains. Therefore, if the number of processors is increased in direct proportion to the size of the problem, the cost associated with elimination remains constant, in contrast with the cost of an elimination-only scheme, which cost would increase more steeply than in simple proportion to problem size.

The new approach preserves the general structure and function of conventional sequential finite-element-method software (see Figure 2). It may be regarded as a model for the construction of the next generation of finite-element analysis packages capable of exploiting computers of parallel architecture. It can be generalized to both distributed- and shared-memory multicomputers, thus eliminating a degree of machine specificity that might otherwise restrict its general usefulness.

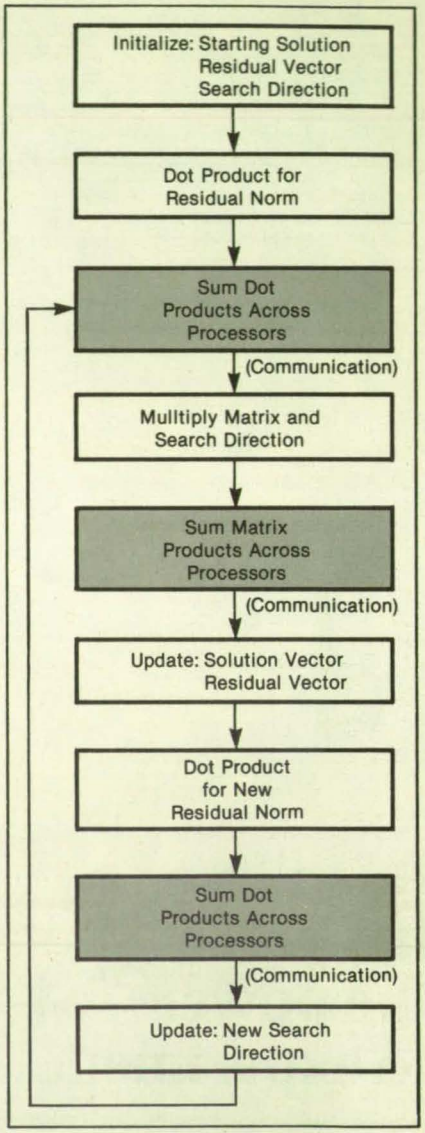


Figure 2. The **Preconditioned-Concurrent-Gradient Algorithm** is modified for the new concurrent finite-element method by the addition of the shaded steps. These steps include the communication tasks, which contain all the machine-specific interprocessor activity and which are isolated from the familiar calculation tasks. The equivalent sequential procedure is recovered by simply deleting the shaded steps.

This work was done by G. A. Lyzenga and A. Raefsky of Caltech and B. Nour-Omid of Lockheed Palo Alto Research Laboratory for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 49 on the TSP Request Card.* *NPO-17602*

Indicator for Pseudomonas Bacteria

A characteristic protein is extracted and detected.

NASA's Jet Propulsion Laboratory, Pasadena, California

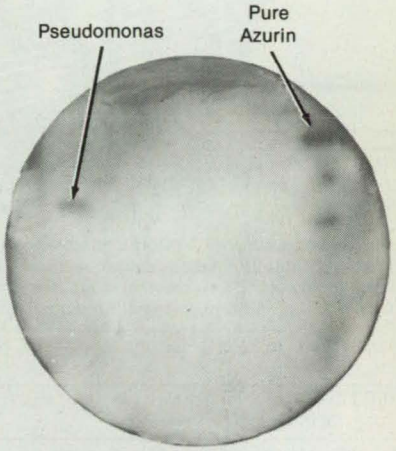
A natural protein marker has been found in *Pseudomonas* bacteria. It may be possible to develop a simple, fast, and accurate test for the marker that can be carried out in a doctor's office. Until now, it has been necessary to use tedious, costly, and time-consuming microbiological techniques to identify the bacteria. The marker is azurin, a protein that contains copper. It can readily be extracted, purified, and used to prepare antibodies.

In a laboratory demonstration of the effectiveness of the marker, a centrifuged extract of *Pseudomonas* culture was separated into components by gel electrophoresis. The separated components were transferred from the gel to a nitrocellulose membrane with a semidry electroblotter.

The free binding sites on the membrane were blocked with bovine serum albumin. The membrane was incubated overnight in a primary antibody solution (antiazurin) and for 2 hours in a secondary antibody solution. An enzymatic staining solution was applied to the wet membrane. The presence of *Pseudomonas* was indicated by dark stains on the membrane (see figure).

This work was done by Ruth Margalit of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 128 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17653.



Pseudomonas Bacteria Appear as a stain on a nitrocellulose membrane. Pure azurin also shows up as a stain.

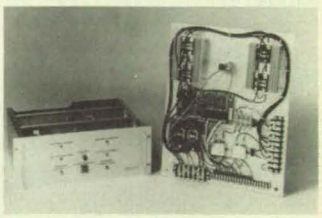
New on the Market

Olympus Corporation, Lake Success, NY, has introduced the Model SC35 **35mm camera** for use with fiberscopes and borescopes. The shape of the camera body is ideal for holding the camera with the scope attached. A remote control is available in 1.2 and 5 meter lengths. The camera accepts film with speeds from ISO 25 to 3200. Its automatic motor-driven advance system moves film to the next frame within 1/2-second.
Circle Reader Action Number 800.

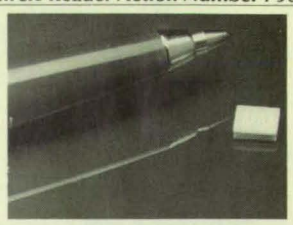
Laser Photonics Inc., Orlando, FL, has introduced the Model CO1 **sealed waveguide carbon monoxide laser.** The mid-infrared laser operates by attaching the laser to the power supply, plugging it in, and turning the key. It is air-cooled, eliminating the need for cryogenically-cooled systems which can be cumbersome to use and expensive to maintain. The CO-1 provides 1W broadband and 500 mW single line power.
Circle Reader Action Number 794.

The Tachion™ **high-speed data acquisition system** from KineticSystems Corporation, Lockport, IL, combines a choice of VAX/VMS host processors with a selection of transient recorders. It is suited for applications requiring high-speed, real-time data, such as engine testing and vibration/acoustic analysis, as well as applications where there is a need to acquire data from multiple analog channels for storage and off-line computer analysis. The system offers up to 1280 analog channels per subsystem; data storage from 200 Mbytes to 56 Gbytes; 15.2 Mbytes/sec throughput; and sampling rates to 2 MHz per channel.
Circle Reader Action Number 798.

Information Handling Services, Englewood, CO, had developed the first military federal specifications service to provide full-text documents, searchable to the sub-paragraph level, on a PC. The **DoD Standardization Service** on CD-ROM offers on-site access to the full text of over 50,000 active Department of Defense standardization documents, as well as information on nearly 180,000 historical documents, active DoD Adopted Industry Standards, Naval Instructions and Directives, DoD Directives, and NASA documents. Exact images of hardcopy originals can be accessed from a PC with this CALS-compliant, SGML-based service.
Circle Reader Action Number 792.



QWIKSWITCH™, offered by PowerTrol Inc., Minneapolis, MN, incorporates unique circuitry for the **coordinated transfer of critical loads** from preferred to alternate sources in the event of a power failure, regardless of the phase relationship between the sources. The device also simplifies isolation of power equipment for maintenance purposes. QWIKSWITCH provides solid-state break-before-make switching operation and thus is not affected by faults on the preferred AC source or by its phase angle. Units are available for use on 120 or 240 volts, 50 or 60 Hz, with single phase ratings up to 90 amperes.
Circle Reader Action Number 796.

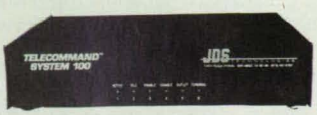


Endevco Corp., San Juan Capistrano, CA, has introduced the Picochip™, a low-cost **piezoelectric accelerometer** designed as a chip component and intended for applications in hybrids, surface mount, or PC boards. The Picochip can be mounted in a TO-series can for PC board application or flat-packs with associated signal conditioning for use in higher-level packages. The accelerometer is physically and electrically integrated into the host electronics.
Circle Reader Action Number 790.

New on the Market

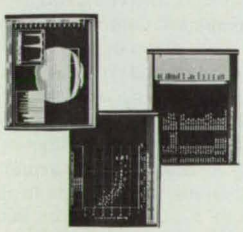
National Instruments Corp., Austin, TX, has introduced the **Virtual Instrument (VI) Developer Toolkit** for the creation of VI panels with the look and feel of physical instruments. The software simplifies the creation of virtual instruments for controlling instrumentation from a DOS-based PC. It is useful for remote operation of RS-232 and GPIB instruments, and for instruments with no front panels, such as plug-in PC boards and VXIbus modules. The toolkit contains an instrument panel compiler, a panel library, a library of button images and fonts, and complete documentation.
Circle Reader Action Number 788.

Virtual Instrument Developer Toolkit from National Instruments has software and documentation



The TeleCommand System 100 from JDS Technologies, San Diego, CA, allows lights, appliances, and electrical devices to be controlled from any telephone, including cordless, car, and cellular portable phones. The **home/office automation system** sends touchtone command codes through existing AC wiring to control lights and appliances. Features include local and remote programmability, two remote access codes, programmable restrictions and momentary control, and rear-panel AC outlet and relay terminal for hard-wired applications.
Circle Reader Action Number 786.

PDA Engineering, Costa Mesa, CA, has developed M/VISION, the first **materials software system** for visualization, selection, and data integration. M/VISION integrates corporate materials data across engineering boundaries with evaluated properties for metals, fiberglass, and structural composites. It enables test engineers to store, manipulate, and analyze raster images from sources such as CAT scans for nondestructive evaluation or failure analysis, and allows design engineers to graphically display properties for optimal materials selection.
Circle Reader Action Number 784.



An advanced **cyanoacrylate adhesive** from Pacer Technology, Rancho Cucamonga, CA, bonds plastics and elastomers together, or in combination with metals. The series PX grade adhesives have a service temperature range of -114°F to +200°F, with impact strengths of 4 to 8 ft-lbs/in^2, and are formulated to produce maximum strength bonds on difficult materials such as Delrin®, MYLAR®, ABS, and PVC.
Circle Reader Action Number 782.

An IBM PC version of the MathType **mathematical equation editor** is available from Design Science Inc., Long Beach, CA. Users can build complex mathematical equations using point and click techniques, and then paste them into their documents. MathType provides 120 templates and over 150 mathematical symbols arranged in a series of pop-up palettes. Users can rearrange and add new symbols, and save up to 32 macro expressions for commonly-used equations.
Circle Reader Action Number 778.

The RF-6500 **software package** from Harris Corporation's RF Communications Group, Rochester, NY, facilitates error-free data communications over HF radio channels. The package employs an adaptive ARQ protocol with forward-error checking to assure accurate message delivery at data rates up to 2400 bps in poor radio propagation conditions. It runs on any IBM PC-AT compatible computer and operates in conjunction with the Harris RF-3466A high-speed modem.
Circle Reader Action Number 780.

New Literature

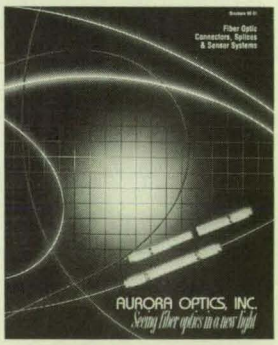
Courtaulds Intrex Corporation, Sylmar, CA, is offering a brochure on its **thin film coating** capabilities for military and aerospace applications. The brochure describes a cost-efficient method of metalizing using magnetron sputtering, electron beam, and vapor deposition techniques.
Circle Reader Action Number 712.

A 56-page catalog from AMP, Harrisburg, PA, provides information on **circular plastic connectors** for automotive, aircraft, instrumentation, computer, and peripheral equipment applications. Covered are four series of lightweight all-plastic connectors for signal, coaxial, and power needs, as well as metal-shell connectors available in shell sizes 14, 22, and 28 as plugs and square flange receptacles. The catalog offers product facts, information on performance characteristics, guidance for choosing connectors and accessories, and data on contact types.
Circle Reader Action Number 718.

The Industrial Products Div. of Chinon America Inc., Mountainside, NJ, has introduced a brochure describing its line of **infrared photoelectric sensors**, including reflex, proximity-measurement and thru-beam versions. The sensors feature a compact, one-piece design and are waterproof and shock-resistant. The brochure details patented device innovations such as the ability to give analog measurement readout in addition to a digital output.
Circle Reader Action Number 714.

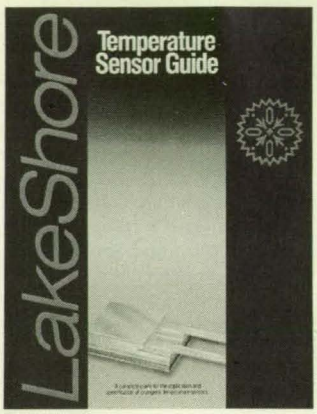
A free brochure from Infometrics, Silver Spring, MD, describes the PC-based TestPro™ System for **nondestructive evaluation (NDE) applications.** TestPro's NDE functions include multi-channel RF signal acquisition, imaging, and analysis for ultrasonic and eddy current NDE; flaw characterization using feature-based signal classification techniques; and transducer characterization including sound-beam profiling with built-in ASTM. TestPro can also perform C- and B-scan imaging with multi-gate amplitude and time-of-flight displays.
Circle Reader Action Number 716.

A new brochure covering **fiber optic connectors, custom cable assemblies, fiber splices, and optical sensors** is available from Aurora Optics, Blue Bell, PA. The brochure features information on the Sure-Snap miniature plastic connector, considered to have the smallest diameter of any fiber optic connector. It also discusses custom cable assemblies, multi-contact hybrid connectors, and high-reliability sensor systems.
Circle Reader Action Number 722.

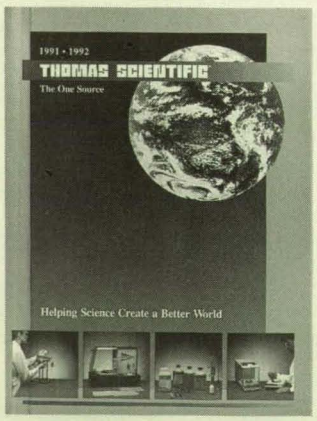


Fiberoptics Technology Inc., Pomfret, CT, is offering a free **fiber optics design guide** covering optical fiber principles. The 12-page guide provides information on fiber construction and composition, how to calculate the critical angle and acceptance for the numerical aperture, the effect of skewed fiber on light transmission, and temperature properties. Also included is data on ringlight styles and applications, and on designing medical and industrial light guides.
Circle Reader Action Number 704.

Information Age Publishing, Exeter, NH, has announced PC Techware, **a directory of personal computer software products for engineering and manufacturing.** The directory describes over 2200 software programs in 84 product categories, including Artificial Intelligence, CAD, CAM, CAE, CIM, Mechanical Engineering, Manufacturing, Inventory Control, PLC Support, Project Management, and Simulation. System requirements, pricing information, and company contacts are provided with each listing.
Circle Reader Action Number 720.

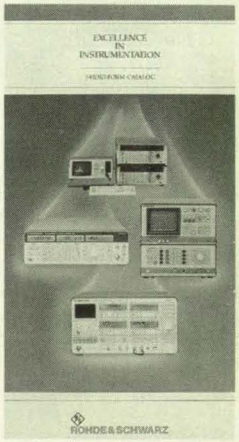


Lake Shore Cryotronics, Westerville, OH, has published a guide for the specification, application, and performance of virtually every type of **cryogenic temperature sensor,** including silicon and gallium-aluminum-arsenide diodes, platinum resistance thermometers, germanium and carbon-glass resistors, rhodium-iron resistors, capacitance sensors, magnetic field Hall sensors, and thermocouples. The guide contains information on physical properties, recommended temperature ranges, magnetic field dependence, calibrations, and measurement techniques.
Circle Reader Action Number 710.



A free hardcover catalog from Thomas Scientific, Swedesboro, NJ, features thousands of **laboratory instruments, supplies, and reagents.** A 50-page index includes over 9000 entries, listing products by trade name, by manufacturer, and by generic category.
Circle Reader Action Number 706.

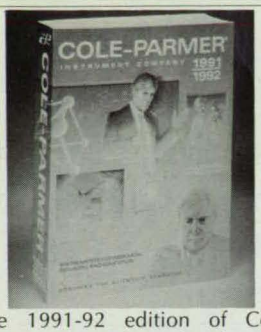
A free 192-page catalog from Huntington Laboratories, Mountain View, CA, spotlights **vacuum components and products** for developing state-of-the-art vacuum systems. Along with more than 200 UHV positioning devices, the catalog introduces dozens of new and patented manipulators, motion feedthroughs, and motion mounting platforms. Also featured are standard and custom vacuum chambers, special bellows assemblies, cryostats, and custom sample heating and cooling assemblies.
Circle Reader Action Number 702.



A 32-page short-form catalog from Rohde & Schwarz, Lanham, MD, details traditional **electronic test equipment** as well as eight new products, including two new signal generators. Other additions include a synthesized oscillator with spectral purity and synthesized stability, radio communication testers for both depot and field use, and a DC plus RMS responding voltmeter with a 20 MHz upper measurement limit. Also covered is a spectrum analyzer with a 5.2 GHz upper frequency limit and a noise level less than -145 dBm.
Circle Reader Action Number 724.

The "1990 P/M Buyers' Guide" from Metal Powder Industries Federation, Princeton, NJ, lists 86 manufacturers of **powder metallurgy (P/M) parts and products.** Information on manufacturing equipment, in-house secondary and quality control capabilities, materials, and specialty products is provided for each company. Products covered include traditional P/M parts such as gears and bearings, cutting tools, forgings, and metal injection molded parts.
Circle Reader Action Number 708.

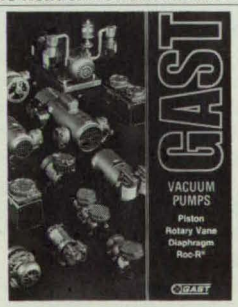
New Literature



The 1991-92 edition of Cole Parmer's general catalog features more than 21,000 **measurement and control instrumentation** products and includes sections on technical data and conversion factor tables, chemical resistance charts, and tubing compatibility tables. New items in the catalog are data acquisition instruments and software, recorders, pressure transmitters and gauges, a Tri-Sense thermohygroanemometer, flowmeters, an infrared flow sensor and unique ultrapure water electrodes.
Circle Reader Action Number 728.

The "Fiber Optic Testing Guide," a free brochure from Fotec Inc., Boston, MA, illustrates the **methods used to test fiber optic cables and networks**. It covers basic test methods for cable loss, transmitter and receiver power, and loopback testing. The guide is applicable to all fiber optic networks, including telecom, datacom, CATV, and military.
Circle Reader Action Number 736.

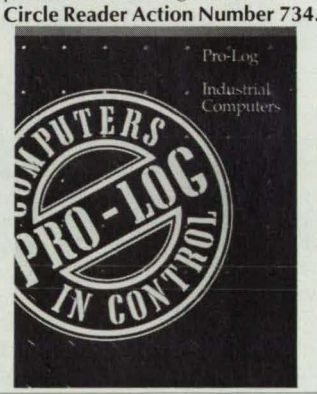
The Instrument Society of America, Research Triangle Park, NC, is offering a tutorial which explores common **temperature measurement techniques** in industrial process measurement and control systems. The book highlights the operative principles of most common sensors, and their selection and use for specific measurements.
Circle Reader Action Number 732.



A new catalog from Gast Manufacturing Corp., Benton Harbor, MI, features four types of **Gast vacuum pumps**: rotary vane, piston, diaphragm, and Roc-R®. The pumps range in size from 1/40 HP to 3HP, up to 55 CFM, and vacuum to 29.5" Hg.
Circle Reader Action Number 738.

An illustrated data sheet is available from Polymer Technologies Inc., Newark, DE, on the Polydamp™ **extensional damping pad**, a lightweight composite with a viscoelastic surface and pressure-sensitive adhesive backing that reduces vibration in thin metal or plastic panels. The literature includes product data, applications, and tables on acoustical performance and physical properties.
Circle Reader Action Number 730.

Pro-Log Corp. Monterey, CA, has introduced a 16-page brochure describing the company's line of **industrial computers,** including the BusBox modular computer system, a new 68030-based processor that operates at 25 MHz. Other units include an AT-compatible processor, a four-axis servo controller, and single cards for communications and networking. Available free of charge, the brochure describes configurations capable of real-time control with parallel processing and support for multitasking software.
Circle Reader Action Number 734.



Cerbec Ceramic Bearing Company, East Granby, CT, is offering a fold-out brochure on its **ceramic bearings and components.** The bearings are made of NORALIDE® silicon nitride, which has a Knoop hardness of 2000 kg/mm — twice the hardness of conventional steels. It is also 60 percent lighter than steel and operates at higher temperatures.
Circle Reader Action Number 726.

NASA's Innovators

Technology 2000, the first-ever national technology transfer conference (November 27-28, Washington, DC), will feature presentations by over 100 of NASA's top researchers and project directors, describing an array of new technologies available for commercialization. In the first of two parts, we spotlight some of these innovators and their leading-edge work.

Twenty miles from Hollywood, **Kevin Hussey** sits in a laboratory making movies. They will not star Patrick Swayze or Julia Roberts, nor will they reap millions at the box office. Nonetheless, Hussey is excited.

"What we are doing is useful across the entire spectrum, from grade school kids to scientists," he said. "I love that."

Hussey supervises the Visualization and Earth Science Applications Group within the Image Processing Applications and Development Section at the Jet Propulsion Laboratory (JPL), Pasadena, CA. His movies involve processing remotely sensed digital data taken from satellite images to produce 3D animations, providing experts with tools to better understand the surfaces on which they work. "Our 3D animations give an armchair view of places we've never been," said Hussey, 35.

The input data includes a digital image and its associated terrain elevation data. Using a ray-casting algorithm, Hussey's team simulates a three-dimensional surface from a two-dimensional image, giving it a more realistic geographic look.

The imagery is enhanced and spatially coregistered with the digital terrain elevation data (DTED). Next, the animation sequence or "flight path" is determined. Then, in a batch, each frame in the sequence is rendered from the registered image and DTED using parameters computed from the flight path. Finally, the sequence is animated by recording each frame to videotape with a computer-controlled video recording system.

The idea to combine animation with Scientific Data Visualization (SDV) came from Hussey's search for ways to make it easier for atmospheric scientists to look at data. His first effort, *L.A.: The Movie*, was created to demonstrate 3D animation techniques. Other JPL movies include *Space to the Moho*, *Miranda: The Movie*, *Earth: The Movie*, and *Mars: The Movie*.

The films average one minute in length and take two people a week to create on VAX and Solbourne computers, provided the data is already prepared. "Putting data together could take anywhere from one day to one year depending on what type it is," said Hussey. "A mosaic of Mars could take a year and $1 million, however, a simple flight path usually takes about a week."

JPL has recently signed a contract with the Canadian filmmaker IMAX to create an 80-second clip entitled *Blue Planet*, scheduled to premier in December at the Smithsonian Air and Space Museum in Washington, DC. The 3D computer movie will explore the planet Neptune through the "eyes" of the Voyager spacecraft.

JPL is also working with the Navy to apply the animation techniques to undersea exploration. They are also exploring applying this idea to electron microscope data. Hussey maintains, however, that the most significant area of application is the classroom and plans to build the software into interactive computer systems. "We can totally revamp and improve how geography is taught in schools around the world," he said. Rather than predetermine a flight path, his idea is to allow users the ability to fly wherever they want on the computer screen.

"It would be like an educational video game," he explained. "You could tell a student that he can only fly a distance of 3000 miles at a maximum altitude of 5000 feet and let him figure out where he would be able to go. For example, he could get over the Rockies, but the Himilayas would present a problem. I think kids would get excited about this."

Hussey's biggest accomplishment was establishing the Digital Image Animation Laboratory. In 1987, he received a $250,000 loan from JPL and built a facility to make it easier to perform SDV animation. He designed it, bought all the equipment, and now runs it.

Hussey joined JPL while studying for a master's in physical geography at San Diego University. "They needed a graduate student to help digitize maps of the California desert," he recalled. By July of that year, he was a full-time staff member. According to Hussey, his degree touches upon basic knowledge of all physical sciences and enables him to translate scientific requirements into computer procedures.

Said Hussey: "I am an educator at heart," explaining he had to choose between working at JPL or teaching elementary school. "I chose JPL because it's an exciting place to work, but I know I will teach some day." ❑

NASA's Kennedy Space Center in Florida is tasked with assembling, testing, launching, and refurbishing the Shuttle Transportation System and its payloads. "The atmosphere at Kennedy is that nothing we do here has ever been done before," said **V. Leon Davis**, chief of Kennedy's Robotics Section, which explores ways automation can improve ground processing operations such as orbiter inspection and assembly. "Automated systems can reduce operational costs, processing time, and hazards to personnel and payloads," said the veteran NASA engineer.

Davis, 45, conceived the idea for Kennedy's Robotic Applications Development Laboratory (RADL), a testbed for new automation techniques. Housed in a 50 by 100 foot high bay facility, the RADL contains general-purpose industrial robots, a variety of advanced sensor systems, and detailed space hardware mockups for experimentation and technology validation.

RADL researchers are currently building a real-time target tracking system for remote umbilical mating operations. A prototype system consists of a vision-based, six-degree-of-freedom tracker attached to an ASEA industrial robot. Using a passive compliance end effector, the robot can mate an umbilical plate mockup to a receptacle plate mounted to a device that simulates an orbiter's motion. The passive compliance device will be replaced by an active system and controller, according to Davis, to reduce mating forces. This technology could be incorporated into future transportation systems such as the Shuttle C and may be useful for refueling commercial and military aircraft, Davis said.

Other RADL projects include the development of an intelligent torque-sensing end effector for operating hand valves in hazardous locations; a teleoperated robot for payload processing; and an automated shuttle radiator inspection device. The latter robot features completely redundant motors, drives, and controls for increased safety and reliability. Said Davis: "I don't know of another totally redundant robotic control system. I'm proud

that it's only taking us two years and a small amount of money to develop a system, compared to what it would take industry to build a similar product."

Davis joined NASA in June 1969 after graduating from Tennessee Technological University with a degree in electrical engineering. His first assignment was working on the Caution Warning Electronics Assembly for Apollo 11. "That was a dream come true," said Davis. "I was offered more money from several other places, but I took the job with NASA because they said I was going to work on the Apollo project."

From 1974 to 1977 he was lead engineer for the automation of electromechanical control systems on the Crawler Transporter, the vehicle used to carry the space shuttle to the launching pad. "We were having a lot of control failure problems," he recalled, "so I ripped the transporter's guts out and installed a system with programmable logic controllers."

Davis also served as a technical consultant on the control/drive systems on the Shuttle Assembly Building and spearheaded control systems work as part of Kennedy's Robotic Development Team before being named chief of the Robotics Section in 1987. His greatest accomplishment, he said, is his success in motivating young NASA engineers. "My section is unique because I have a lot of young people," he explained. "I like getting them excited about projects, winding them up, turning them loose, and watching them excel." ❑

"My curiosity motivates me," said **Dr. Theodore J. Wydeven**, a veteran scientist at NASA's Ames Research Center. "It's interesting to see whether or not a hypothesis proves true through research."

Wydeven's work on physico-chemical water recycling for space missions could benefit space station Freedom and future planetary spacecraft by limiting costly weight of water provisions. Wydeven began his research when he found it cost $5000 to lift one pound of weight into space, and astronauts need more water in space than food and oxygen combined.

Testing of Wydeven's recycling techniques using laundry and hygiene water is underway at the Ames Center in California and Marshall Space Flight Center in Alabama. Studies include real-time monitoring of water samples and distillation processes to reclaim water from urine.

"We are not relying on quantum leaps or technological breakthroughs to optimize the system," said Wydeven, 54. "We are miniaturizing the system and making it economically sound for use."

Although designed for space, the system is applicable to terrestrial water needs where extensive water recycling is required or where advanced water treatment is essential to meet EPA health standards.

NASA recruited Wydeven in 1964 from the University of Washington, where he earned his PhD in physical chemistry. In 1977, he began developing a scratch-resistant coating for plastic helmet visors for the Johnson Space Center. His patented coating process was licensed to Foster Grant in 1983 for use on plastic sunglasses and non-prescription reading glasses. Since then, Foster Grant has sold "tens of millions of dollars" worth of scratch-resistant sunglasses.

The invention has benefitted both NASA and Wydeven. It holds the record for most units sold under a NASA license and is second in highest royalties to NASA.

Wydeven was nominated by NASA and inducted into the Space Technology Hall of Fame in 1989 for his work on the coating process. He has also served as a consultant for companies interested in the uses of thin film coating.

Each year, Wydeven teaches a "Life in Space" seminar about water recycling at Stanford University. Teaching is one of his loves, and Wydeven has considered joining the Peace Corps to educate underprivileged children. His wife, Julie Ann Wydeven, teaches children with learning disabilities at Santa Fe State University.

The Ames scientist relaxes by skiing near Lake Tahoe and he also enjoys swimming and hiking. He is a numismatist, or coin collector, and has an extensive array of American and Japanese currency.

Aside from the attention Wydeven has drawn from his inventions and patents, he is most proud of his more than 90 papers in technical and scientific journals. "Recognition from peers. . . that's what motivates most scientists," he said. "That they would consider me a contributor to the field and worthy of publication, that's what matters." ❑

Robert T. Savely investigates the potential contribution of artificial intelligence (AI) technology to training and education. Savely manages the Software Technology Branch at NASA's Johnson Space Center in Houston, where his 100-member staff is developing Intelligent Computer-Aided Training (ICAT) systems for use within NASA by astronauts, flight controllers, and systems engineers.

"Training is the basic problem every business faces," Savely, 55, said. "The cost to train each employee cuts into everyone's budget." The purpose of ICAT is to cost-effectively train employees while freeing experienced personnel to perform other tasks. ICAT systems simulate the behavior of an instructor observing a trainee, responding to help requests, diagnosing and remedying trainee errors, and proposing challenging new training scenarios.

Another ICAT function is to retrain experienced employees. "In any environment, retraining is necessary for tasks people have not performed recently," Savely explained. Astronauts, for example, could use the AI system to "brush up" on procedures before embarking on a mission.

ICAT will benefit the education field by providing a one-on-one tutor relationship not economically feasible in the classroom, Savely said. The Intelligent Physics Tutor, an ICAT technology spinoff, teaches students problem-solving skills for high school and college physics. A three-year program initiated in 1988, the tutor is intended for integration with the lecture and laboratory portions of the typical instructional program. Its strength lies in its ability to continually observe the student, develop problem solutions, and intervene with assistance directed at the student's difficulty and tailored to the student's skill level and learning style.

The program has been implemented on the Apple Macintosh II computer using the C language and features extensive graphics, video, and sound. It is currently being evaluated at high schools in League City, TX and Columbus, Ohio. The end goal is to have the software mass-produced and delivered economically to high schools and colleges nationwide. In addition, the methodologies employed and much of the software created could be used to produce intelligent tutors for other disciplines such as chemistry and engineering.

Savely joined NASA in 1963, drawn by the "challenge of the space program." Over his 27-year career, he has earned numerous NASA awards. He was honored with the Presidential Medal of Freedom as a member of the Apollo 13 operations team and, in 1988, was named Technical Person of the Year by the Clear Lake Council of Technical Societies. Savely and three coworkers received a Space Act Award of $40,000 for the development of the C Language Integrated Production System (CLIPS), the first inexpensive, high-performance, software tool for constructing expert systems. CLIPS has been successfully implemented on over 50 different computing systems, from the IBM PC to the Cray 2 supercomputer.

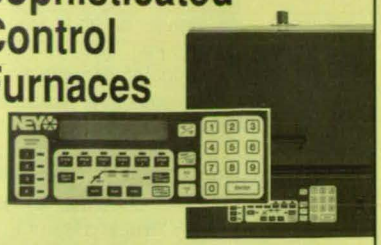
In 1982, Savely founded the Johnson Center's Software Technology Branch (formerly the Artificial Intelligence Lab) and has directed and contributed to the design of the Shuttle Onboard Navigation System, which contains several complex expert systems for failure detection, isolation, and reconfiguration. In addition to his NASA duties, Savely serves as a consultant on artificial intelligence to both the U.S. Air Force and the Navy.

Local politics occupy much of Savely's time away from the Johnson Center. As president of the Clear Lake City Water Authority, he and the five-member board of directors establish policies for water control, sewage, and drainage for Harris County, a Houston suburb. He is an appointed member of City of Houston Mayor's Task Force which advises the mayor on issues like police protection, emergency services, street maintenance, and parks and recreation. "I believe everyone should contribute to the welfare of the community," he said. "People need to do for themselves rather than expect someone else to do the job at a higher cost."

For relaxation, Savely enjoys photography, fishing and tending to his tropical plants. Further, he and wife Judithe raise koi-- Japanese carp-- in their backyard pond. "It's like an aquarium," Savely said, "but a step up from the goldfish I had when I was young." ❑

For more information on Technology 2000 and its presenters, turn to page 33.

Sophisticated Control Furnaces



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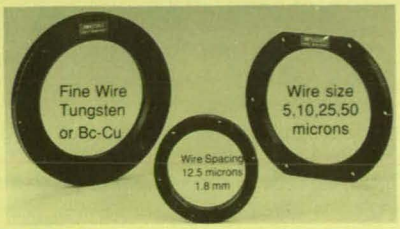

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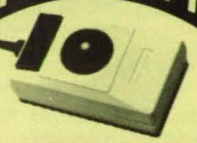

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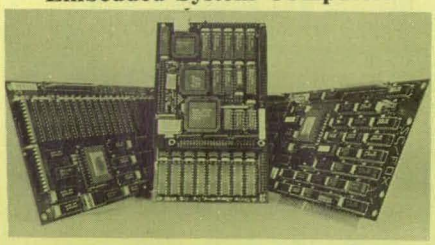

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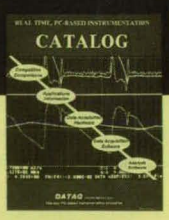

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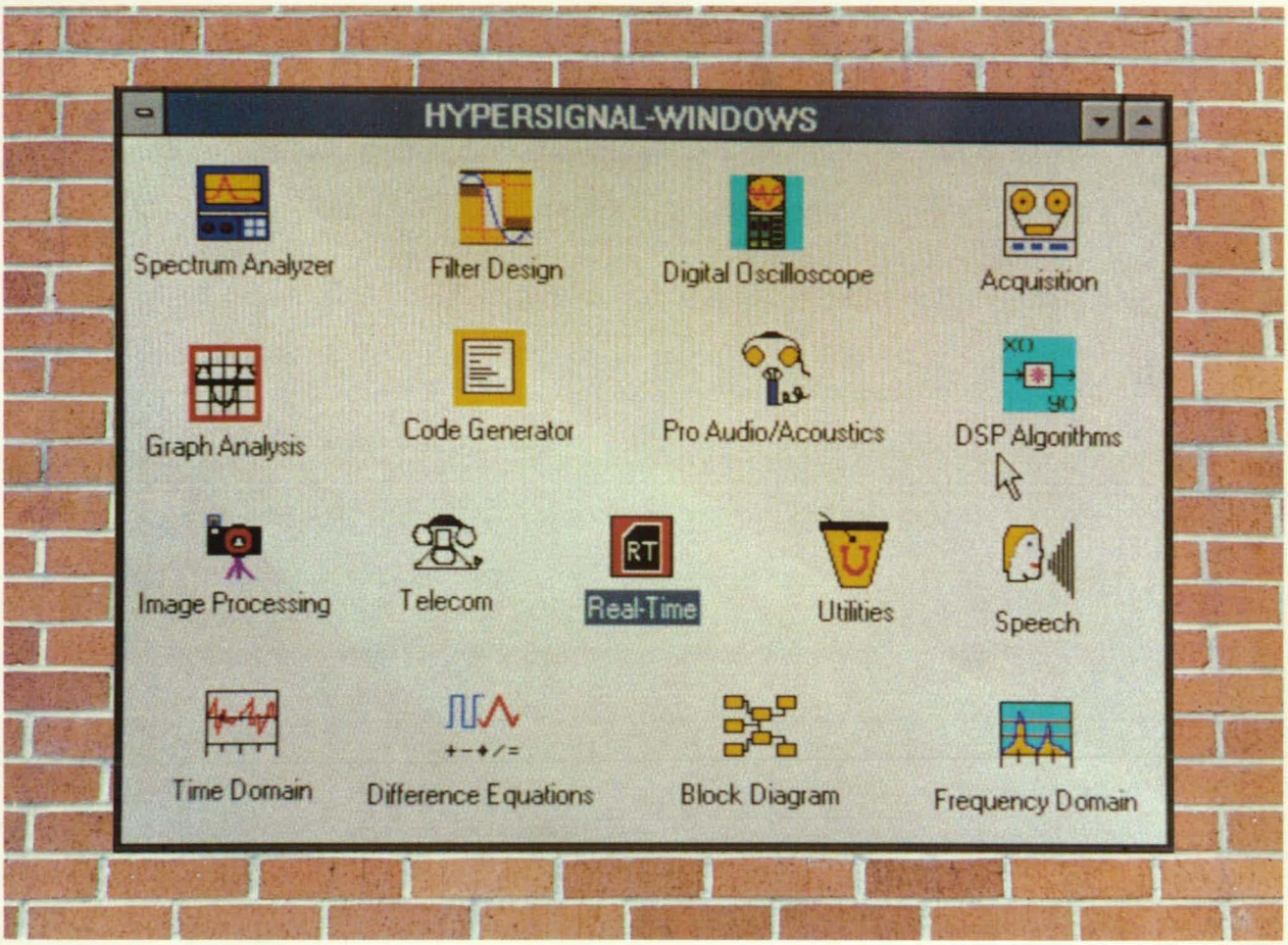

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